

Eriophyoidea and allies: where do they belong?

Author: Zhang, Zhi-Qiang

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>

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Eriophyoidea and allies: where do they belong?

ZHI-QIANG ZHANG^{1, 2}

¹ Landcare Research, 231 Morrin Road, Auckland, New Zealand; ZhangZ@landcareresearch.co.nz

² School of Biological Sciences, the University of Auckland, Auckland, New Zealand

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 Lingquist 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, Tetranychosidea, 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.

References

- Amrine, J.W., Jr. & Stasny, T.A. (1994) *Catalogue of the Eriophyoidea (Acari: Prostigmata) of the World*. Indira Publishing House, West Bloomfield, Michigan, USA, 798 pp.
- Amrine, J.W., Jr, Stasny, T.A. & Flechtman, C.H.W. (2003) *Revised Keys to World Genera of Eriophyoidea (Acari: Prostigmata)*. Indira Publishing House, West Bloomfield, 244 pp.
- André, M. (1949) Ordre des Acariens (Acari Nitsch., 1818). *Traité de Zoologie*, 6, 794–892.
- Azevedo, L.H., Castilho, R.C. & Moraes, G.J.De (2016) Suitability of the litchi erineum mite, *Aceria litchii* (Keifer), as prey for the mite *Phytoseius intermedius* Evans & MacFarlane (Acari: Eriophyidae, Phytoseiidae). *Systematic and Applied Acarology*, 21(3), 270–278.
<https://doi.org/10.11158/saa.21.3.2>
- Baker, E.W. & Wharton, G.W. (1952) *An Introduction to Acarology*. MacMillan, New York, USA, 465 pp.
- Berlese, A. (1885) Acarorum systematis specimen. *Bolletino della Societa Entomologica Italiana*, 17, 121–135.
- Bolton, S.J., Chetverikov, P.E. & Klompen, H. (2017) Morphological support for a clade comprising two vermiform mite lineages: Eriophyoidea (Acariformes) and Nematalycidae (Acariformes). *Systematic and Applied Acarology*, 22(8), 1096–1131.
<http://doi.org/10.11158/saa.22.8.2>
- Canestrini, G. (1891) Abbozzo del Sistema Acarologico. Abbozzo del sistema acarologico. *Atti del Reale Istituto Veneto di Scienze, Lettere ed Arti*, 7(2), 699–725.
- Chandrapatya, A., Konvipasruang, P. & Amrine J.W.Jr. (2016) New eriophyoid mites from Thailand. *Systematic and Applied Acarology*, 21(1), 55–78.
<https://doi.org/10.11158/saa.21.1.5>
- Chetverikov, P.E. & Craemer, C. (2016) Sierraphytoptines (Eriophyoidea: Phytoptidae) from relict eudicots: reassignment of *Sierraphytoptus taiwanensis* to a new genus *Solenoplailobus* and refinement of generic diagnosis of *Austracus*. *Systematic and Applied Acarology*, 21(6), 745–758.
<https://doi.org/10.11158/saa.21.6.3>
- Chetverikov, P.E., Cvrković, T., Makunin, A., Sukhareva, S., Vidović, B. & Petanović, R. (2015) Basal divergence of Eriophyoidea (Acariformes, Eupodina) inferred from combined partial COI and 28S gene

- sequences and CLSM genital anatomy. *Experimental & Applied Acarology*, 67, 219–245.
<http://dx.doi.org/10.1007/s10493-015-9945-9>
- Chetverikov, P.E., Hörweg, C., Kozlov, M.I. & Amrine, J.W.Jr. (2016) Reconditioning of the Nalepa collection of eriophyoid mites (Acariformes, Eriophyoidea). *Systematic and Applied Acarology*, 21(5), 583–595.
<https://doi.org/10.11158/saa.21.5.3>
- Chetverikov, P.E. & Kostin, N.A. (2016) Laser cutting microdissection of the cuticle of microarthropods: a case study of eriophyoid mites (Acari, Eriophyoidea). *Systematic and Applied Acarology*, 21(5), 698–702.
<https://doi.org/10.11158/saa.21.5.11>
- Chetverikov, P.E. & Petanović, R.U. (2016a) Longest endoparasitic eriophyoid mite (Acari, Eriophyoidea): description of *Novophytoptus longissimus* n. sp. and remarks on size limits in eriophyoids. *Systematic and Applied Acarology*, 21(11), 1547–1563.
<https://doi.org/10.11158/saa.21.11.10>
- Chetverikov, P.E. & Petanović, R.U. (2016b) New observations on early-derivative mite *Pentasetacus araucariae* (Schliesske) (Acariformes: Eriophyoidea) infesting relict gymnosperm *Araucaria araucana*. *Systematic and Applied Acarology*, 21(8), 1157–1160.
<https://doi.org/10.11158/saa.21.8.15>
- Druciarek, T., Kozak, M., Maroufpoor, M. & Lewandowski, M. (2016) Morphological variability of *Phyllocoptes adaluis* female forms (Acari: Eriophyoidea), with a supplementary description of the species. *Systematic and Applied Acarology*, 21(2), 181–194.
<https://doi.org/10.11158/saa.21.2.3>
- Duarte, M.E, Chetverikov, P.E., Silva, E.S. & Navia, D. (2016) Three new species of eriophyoid mites (Acariformes, Eriophyoidea) from *Lippia alba* (Verbenaceae) from Brazil, and remarks on the thorn-like spermathecal process. *Systematic and Applied Acarology*, 21(9), 1225–1249.
<https://doi.org/10.11158/saa.21.9.7>
- Han, X., Hong, X.-Y. & Zhang, Z.-Q. (2016) Identification of *Aceria genistae* species complex (Acari: Eriophyidae) from broom, gorse and related plants (Fabaceae: Genisteae) in western US and a new record of *Aculops hussongi*. *Systematic and Applied Acarology*, 21(11), 1525–1533.
<https://doi.org/10.11158/saa.21.11.8>
- Han, X., Xue, X.-F. & Hong, X.-Y. (2017) Eriophyoid mites from Hengduan Mountains, southwestern China with descriptions of nine new species (Acari, Eriophyoidea). *Systematic and Applied Acarology*, 22(8), 1132–1166.
<http://doi.org/10.11158/saa.22.8.3>
- Hughes, T.E. (1959) *Mites or the Acari*. University of London The Athlone Press, London, 225 pp.
- Keifer, H.H. (1975) Eriophyoidea Nalepa. In: Jeppson, L.R., Keifer, H.H. & Baker, E.W., (Eds.). *Mites injurious to economic plants*. University of California Press, Berkeley, California, USA, pp. 327–396.
- Kethley, J.B. (1982) Acariformes, Prostigmata. In: Parker, S.B., (Ed.). *Synopsis and Classification of Living Organisms*, Vol. 2. McGraw Hill, New York, pp. 117–146.
- Kethley, J.B. (1990) Acarina: Prostigmata (Actinedida). In: Dindal, D.L., (Ed.) *Soil Biology Guide*. John Wiley & Sons, New York, pp. 667–756.
- Kramer, P. (1877) Grundzüge zur Systematik der Milben, *Archiv für Naturgeschichte*, 43, 1, 215–247
- Krantz, G.W. (1970) *A Manual of Acarology*. Oregon State University Book Stores, Corvallis, Oregon, USA, 335 pp.
- Krantz, G.W. (1978) *A Manual of Acarology. Second edition*. Oregon State University Book Stores, Corvallis, Oregon, USA, 509 pp.
- Krantz, G.W. & Lindquist, E.E. (1979) Evolution of phytophagous mites (Acari). *Annual Review of Entomology*, 24, 121–158.
<https://doi.org/10.1146/annurev.en.24.010179.001005>
- Lam, W. & Zhang, Z.-Q. (2016) Hotspots of mite new species discovery: Parasitiformes (2013–2015). *Systematic & Applied Acarology*, 21(12), 1693–1709.
<http://doi.org/10.11158/saa.21.12.10>
- Li, F.-L., Li, T., Su, J., Yang, S., Wang, P.-L. & Zhang, J.-P. (2016) Temporal and spatial differences in gall induction on *Haloxylon* by *Aceria haloxylonis* (Acari: Eriophyidae) in the Gurbantünggüt Desert. *Systematic and Applied Acarology*, 21(12), 1670–1680.
<https://doi.org/10.11158/saa.21.12.8>
- Li, G.-Y. & Zhang, Z.-Q. (2016) Hotspots of mite new species discovery: Sarcoptiformes (2013–2015). *Zootaxa*, 4208(2), 101–126.

- <http://doi.org/10.11646/zootaxa.4208.2.1>
- Lindquist, E.E. (1976) Transfer of the Tarsocheyleidae to the Heterostigmata, and reassignment of the Tarsonemina and Heterostigmata to lower hierarchic status in the Prostigmata (Acari). *Canadian Entomologist*, 108, 23–48.
- <http://dx.doi.org/10.4039/Ent10823-1>
- Lindquist, E.E. (1996a) Nomenclatural problems in usage of some family and genus names. In: Lindquist, E.E., Sabelis, M.W. & Bruin, J., (Eds.), *Eriophyoid Mites – Their Biology, Natural Enemies and Control*, vol. 6. Elsevier, Amsterdam, Netherlands, pp. 89–99.
- Lindquist, E.E. (1996b) Phylogenetic relationships. In: Lindquist, E.E., Sabelis, M.W., Bruin, J., (Eds.), *Eriophyoid Mites – Their Biology, Natural Enemies and Control*, vol. 6. Elsevier, Amsterdam, Netherlands, pp. 301–327.
- Lindquist, E.E. & Amrine, J.A. Jr (1996) Systematics, diagnosis for major taxa, and keys to families and genera. In: Lindquist, E.E., Sabelis, M.W., Bruin, J., (Eds.), *Eriophyoid Mites – Their Biology, Natural Enemies and Control*, vol. 6. Elsevier, Amsterdam, Netherlands, pp. 33–87.
- Lindquist, E.E., Krantz, G.W. & Walter, D.E. (2009) Classification. In: Krantz, G.W. & Walter, D.E., (Eds.), *A manual of acarology*. Texas Tech University Press, Lubbock, TX, pp. 97–103.
- Lindquist, E.E., Sabelis, M.W. & Bruin, J. (Eds.) *Eriophyoid Mites – Their Biology, Natural Enemies and Control*, vol. 6. Elsevier, Amsterdam, Netherlands, 790 pp.
- Liu, D., Yi, T.-C., Xu, Y. & Zhang, Z.-Q. (2013) Hotspots of new species discovery: new mite species described during 2007 to 2012. *Zootaxa*, 3663, 1–102.
- <https://doi.org/10.11646/zootaxa.3663.1.1>
- Liu, J.-F. & Zhang, Z.-Q. (2016) Hotspots of mite new species discovery: Trombidiformes (2013–2015). *Zootaxa*, 4208(1), 1–45.
- <http://doi.org/10.11646/zootaxa.4208.1.1>
- Lotfollahi, P., de Lillo, E. & Irani-Nejad, K.H. (2017) Contribution on *Aceria* spp. (Acari: Trombidiformes: Eriophyoidea) from southwest of East Azerbaijan province in Iran: new records and description of two new species. *Systematic and Applied Acarology*, 22(8), 1167–1180.
- <http://doi.org/10.11158/saa.22.8.4>
- Lotfollahi, P., Gol, A., Irani-Nejad, K.H. & Sadeghi, H. (2016) Eriophyid mites (Acari: Trombidiformes: Eriophyidae) from Elm trees in Iran. *Systematic and Applied Acarology*, 21(3), 367–374.
- <https://doi.org/10.11158/saa.21.3.11>
- Murray, A. (1877) *Economic Entomology, Aptera*. Chapman and Hall, Piccadilly, 433 pp.
- Oudemans, A.C. (1902) Classificatie der Acari. *Tijdschrift voor Entomologie*, 45, 58–60.
- Oudemans, A.C. (1906) Nieuwe classificatie der Acari. *Entomologische Berichten*, 2, 43–46.
- Oudemans, A.C. (1923) Studie over de sedert 1877 ontworpen systemen der Acari; nieuwe classificatie; phylogenetische beschouwingen. *Tijdschrift voor entomologie*, 66, 49–85.
- Reuter, E. (1909) Zur Morphologie und Ontogenie der Acariden mit besonderer Berücksichtigung von Pediculopsis graminum. *Acta Societas Scientiarum Fennicae*, 36, 1–288.
- Schmidt, A.R., Jancke, S., Lindquist, E.E., Ragazzi, E., Roghi, G., Nascimbene, P.C., Schmidt, K., Wappler, T. & Grimaldi, D.A. (2012) Arthropods in amber from the Triassic Period. *Proceedings of the National Academy of Sciences of the USA*, 109, 14796–14801.
- <http://dx.doi.org/10.1073/pnas.1208464109>
- Sidorchuk, E.A., Schmidt, A.R., Ragazzi, E., Roghi, G. & Lindquist, E.E. (2015) Plant-feeding mite diversity in Triassic amber (Acari: Tetrapodili). *Journal of Systematic Palaeontology*, 13, 129–151.
- <http://dx.doi.org/10.1080/14772019.2013.867373>
- Tan, M., Mo, Y., Lu, W. & Wang, G. (2016) Two new genera and four new species of the tribe Anthocoptini (Acari: Eriophyidae) from South China. *Systematic and Applied Acarology*, 21(6), 759–777.
- <https://doi.org/10.11158/saa.21.6.4>
- Thor, S. (1929) Über die Phylogenie und Systematik der Acarina, mit Beiträgen zuresten Entwicklungsgeschichte einzelner Gruppen. *Nyt Magazine for Naturvidenskaberne*, 67, 145–210.
- Trouessart, E.L. (1892) Considérations générales sur la classification des Acariens, suivies d'un essai de classification nouvelle. *Revue des Sciences Naturelles, Paris*, 2, 20–54.
- Ueckermann, E.A. (ed) (2010) *Eriophyoid Mites: Progress and Prognoses*. Springer, Dordrecht, 307 pp.
- Vidović, B., Cvrković, T., Rančić, D., Marinković, S., Cristofaro, M., Schaffner, U. & Petanović, R. (2016) Eriophyid mite *Aceria artemisiifoliae* sp.nov. (Acari: Eriophyoidea) potential biological control agent of invasive common ragweed, *Ambrosia artemisiifolia* L. (Asteraceae) in Serbia. *Systematic and Applied*

- Acarology*, 21(7), 919–935.
<https://doi.org/10.11158/saa.21.7.6>
- Vitzthum, H. (1931) Ordnung der Arachnida; Acari (Milben). In: W. Kükenthal (Ed.). *Handbuch der Zoologie* 3, Heft 2, Teil 3, Lief. 1.
- Xue, X.-F., Guo, J.-F., Dong, Y., Hong, X.-Y. & Shao, R. (2016) Mitochondrial genome evolution and tRNA truncation in Acariformes mites: new evidence from eriophyoid mites. *Scientific Reports*, 6, 18920.
<http://dx.doi.org/10.1038/srep18920>
- Xue, X.-F., Dong, Y., Deng, W., Hong, X.-Y. & Shao, R. (2017) The phylogenetic position of eriophyoid mites (superfamily Eriophyoidea) in Acariformes inferred from the sequences of mitochondrial genomes and nuclear small subunit (18S) rRNA gene. *Molecular Phylogenetics and Evolution*, 109, 271–282.
<https://doi.org/10.1016/j.ympev.2017.01.009>
- Zhang, Z.-Q., Fan, Q.-H., Pesic, V., Smit, H., Bochkov, A.V., Khaustov, A.A., Baker, A., Wohltmann, A., Wen, T.-H., Amrine, J.W., Beron, P., Lin, J.-Z., Gabrys, G. & Husband, R. (2011) Order Trombidiformes Reuter, 1909. In: Zhang, Z.-Q. (Ed.). *Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness*. *Zootaxa*, 3148, 129–138.

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