Zootaxa 3780 (1): 135–152
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

http://dx.doi.org/10.11646/zootaxa.3780.1.5
http://zoobank.org/urn:lsid:zoobank.org:pub:86473618-EA0D-40A4-BDE0-452A60233ED8

New host records for European Acroceridae (Diptera), with discussion of species limits of *Acrocera orbiculus* (Fabricius) based on DNA-barcoding

CHRISTIAN KEHLMAIER[1] & JORGE MOTA ALMEIDA[2]

[1]*c/o Senckenberg Natural History Collections Dresden, Museum of Zoology, Koenigsbruecker Landstrasse 159, 01109 Dresden, Germany. E-mail: kehlmaier@web.de*
[2]*Rua da Póvoa Dão, Casal Jusão, P-3500-532 Silgueiros, Viseu, Portugal. E-mail: jorgemotalmeida@gmail.com*

Abstract

New European host records for the Acroceridae species *Acrocera orbiculus* (Fabricius) and *Ogcodes reginae* Trojan are reported. *Acrocera orbiculus* was reared from *Amaurobius erberi* (Keyserling), and *O. reginae* from *Clubiona leucaspis* (Simon) and *Evarcha jucunda* (Lucas). Where possible, DNA-barcodes are presented for reared endoparasitoids and their host specimens. Based on mitochondrial COI, the intraspecific genetic variability of 15 western Palaearctic *A. orbiculus* is discussed. Maximum likelihood analysis reveals two clades, though they have low statistical support and no distinct barcoding gap. Therefore, we consider all barcoded specimens of *A. orbiculus* to be a single biological species with a high degree of phenotypic plasticity regarding body size and coloration. Based on molecular and morphological evidence, *Paracrocera kaszabi* Majer, *Paracrocera manevali* Séguy and *Paracrocera minuscula* Séguy are placed in synonymy with *A. orbiculus*. The male of the Canary Islands endemic *Acrocera cabrerae* Frey is described for the first time.

Key words: small-headed flies, spider flies, *Ogcodes reginae*, Araneomorphae, new synonymies, intra-specific genetic variation

Introduction

Currently, about 530 species of Acroceridae or small-headed flies are placed within three subfamilies comprising 55 genera (Barneche *et al.* 2013; Schlinger *et al.* 2013; Winterton & Gillung 2012). Most known Acroceridae larvae develop as endoparasitoids in the opisthosoma of true spiders (Araneae), undergoing a distinct hypermetamorphosis, i.e., each larval instar is morphologically unique and has a distinctive lifestyle (Schlinger 2003). Known exceptions include the Neotropical *Sphaerops appendiculata* Philippi, developing as an ectoparasitoid on *Ariadna maxima* (Nicolet) (Segestriidae) (Schlinger 1987), and recent findings by Sferra (1986) and Kerr & Winterton (2008) remarking the presence of first instar larvae on Acari. Synopses of the family's life history are given by Nartshuk (1997) and Schlinger (2003). The first detailed phylogenetic reconstruction of the family was presented by Winterton *et al.* (2007), which rendered Acrocerinae paraphyletic with *Acrocera* Meigen and *Sphaerops* Philippi situated at the base of the Acroceridae.

Since the discovery of the parasitic lifestyle in Acroceridae (Menge 1866), at least 63 species (about 12% of the world fauna) have been recorded from 24 of the more than 100 spider families (Schlinger 1987, 2003; Barneche *et al.* 2013). At present, no comprehensive index of host-parasite relationships can be found in the literature, but extensive overviews were compiled by Eason *et al.* (1967) and Schlinger (1987).

Acrocera orbiculus (Fabricius), also known as the 'top-horned hunchback' (Stubbs & Drake 2001), is a Holarctic species and one of the most frequently collected Acroceridae in the western Palaearctic. Chvála (1980) commented extensively on the taxonomic challenge of *A. orbiculus* and concluded that *Syrphus globulus* Panzer is synonymous with *A. orbiculus*, as originally proposed by Gil Collado (1929—under the name *A. globulus*) and Schlinger (1965), but that a possible second distinct unnamed species has been addressed as *A. globulus* by various authors (Sack 1936; Trojan 1956; Weinberg 1966). He listed this taxon as "sp. (*globula* PANZ.)" in his identification key and differentiates it from *A. orbiculus* by the somewhat darkened femora and a slightly larger

Accepted by N. Evenhuis: 7 Feb. 2014; published: 20 Mar. 2014

Acknowledgments

It is our pleasure to send a hearty thank you to the following people and institutions for their support and advice: Hélène Dumas (La Ciotat, France) for sharing her rearing record of *O. reginae*; Frits Broekhuis (Amersfoort, The Netherlands) for sending in his *A. orbiculus* and for his excellent photographic documentation; Naturdata Portugal (courtesy of Ricardo Ramos da Silva) for passing on details on their finding of *O. reginae*; Antonio Camacho (Tenerife, Las Canarias, Spain) and Emídio Machado (Laranjeiro, Almada, Portugal) for putting their specimen photos at our disposal; Dr. Thomas Pape (ZMUC) for arranging the loan of material in his custodial care; Jenny Pohl (MNHU) and Dr. Christophe Daugeron (MNHN) for checking the presence of type specimens; Dr. Babak Gharali (Ghazvin, Iran), Matt N. Smith (Winnersh, UK), Dr. Martin Speight (Dublin, Ireland) and Phil Withers (Sainte Euphémie, France) for contributing adult *A. orbiculus* for study; Mercedes París (Madrid, Spain) for providing rare literature; Ke-Ke Huo (Hanzhong, China) and Shulian Hao (Tianjin, China) for helping to locate the locus typicus of *A. paitana*; Jéssica Gillung (São Paulo, Brazil) and Chris Borkent (Sacramento, USA) for their helpful comments and suggestions. Part of the material originates from the "Diptera Stelviana" project (courtesy of Dr. Joachim Ziegler at MNHU) and the Terrestrial Fauna component of the ATBI Mercantour, Parc National du Mercantour / UMR7205 MNHN Paris (courtesy of Dr. Christophe Daugeron at MNHN). The first author is grateful for the financial support received from the SYNTHESYS Project http://www.synthesys.info/ financed by European Community Research Infrastructure Action under the FP7 'Capacities' programme to carry out collection work at ZMUC in Copenhagen.

Literature

Barneche, J.A., Gillung, J.P. & González, A. (2013) Description and host interactions of a new species of *Exetasis* Walker (Diptera: Acroceridae), with a key to species of the genus. *Zootaxa*, 3664 (4), 525–536. http://dx.doi.org/10.11646/zootaxa.3664.4.6

Barraclough, D.A. & Croucamp, W. (1997) A new South African species of *Ogcodes* Latreille (Diptera: Acroceridae) reared from a sac spider of the genus *Cheiracanthium* Koch (Miturgidae). *Annals of the Natal Museum*, 38, 55–60.

Boie, F. (1838) Zur Verwandlungsgeschichte inländischer Zweiflügler. *Naturhistorisk Tidsskrift,* 2, 234–248.

Cady, A., Leech, R., Sorkin, L., Stratton, G. & Caldwell, M. (1993) Acrocerid (Insecta: Diptera) life histories, behaviours, host spiders (Arachnida: Araneida), and distribution records. *The Canadian Entomologist*, 125, 931–944. http://dx.doi.org/10.4039/ent125931-5

Chvála, M. (1980) Acroceridae (Diptera) of Czechoslovakia. *Acta Universitatis Carolinae, Biologica*, 1977, 253–267.

Cole, F.R. (1919) The dipterous family Cyrtidae in North America. *Transactions of the American Entomological Society*, 45, 1–79.

Coquillett, D.W. (1910) The Type-species of the North American genera of Diptera. *Proceedings of the United States National Museum*, 37, 499–647. http://dx.doi.org/10.5479/si.00963801.37-1719.499

Darriba, D., Taboada, G.L., Doallo, R. & Posada, D. (2012) jModelTest 2: more models, new heuristics and parallel computing. *Nature Methods*, 9 (8), 772. http://dx.doi.org/10.1038/nmeth.2109

de Jong, H. (2001) *Acrocera sanguinea* and *A. trigramma* in copula (Acroceridae). *Studia dipterologica*, 8, 187–188.

de Jong, H., Noordam, A.P. & Zeegers, T. (2000) The Acroceridae (Diptera) of The Netherlands. *Entomologische Berichten*, 60, 171–179.

Dušek, J. & Láska, P. (1974) Influence of temperature during pupal development on the colour of syrphid adults (Syrphidae, Diptera). *Folia facultatis scientarum naturalium universitatis Purkynianae Brunensis*, 15, 77–81.

Eason, F.R., Peck, W.B. & Whitcomb, W.H. (1967) Notes on spider parasites, including a reference list. *Journal of the Kansas Entomological Society*, 40, 422–434.

Edwards, M. (1984) A further observation of swarming behaviour in *Acrocera orbicula* (F.) (Dipt., Acroceridae). *The Entomologist's Monthly Magazine*, 120, 236.

Erichson, W.F. (1840) *Entomographien. Heft 1*. F.H. Morin, Berlin, 183 pp.

Fabricius, J.C. (1787) *Mantissa insectorvm sistens eorvm species nvper detectas adiectis characteribvs genericis, differentiis specificis, emendationibvs, observationibvs.* Tom. II. Proft, Hafniae, 382 pp.

Felsenstein, J. (1985) Confidence limits on phylogenies: an approach using the bootstrap. *Evolution*, 39, 783–791. http://dx.doi.org/10.2307/2408678

Folmer, O., Black, M., Hoeh, W., Lutz, R. & Vrijenhoek, R. (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology*, 3, 294–299.

Frey, R. (1936) Die Dipterenfauna der Kanarischen Inseln und ihre Probleme. *Commentationes Biologicae*, 6 (1), 1–237.
Gerstäcker, A. (1856) Zur Kenntnis der Henopier. *Entomologische Zeitung zu Stettin*, 17(11–12), 339–361.
Gilbert, F. (2005) The evolution of imperfect mimicry in hoverflies. Available from: http://eprints.nottingham.ac.uk/96/1/ImperfectMimicry.pdf (accessed 25 February 2014)
Gil Collado, J. (1929) Círtidos españioles y marroquies del Museo de Madrid (Dipt. Cyrt.). *Memorias de la Real Sociedad Española de Historia Natural*, 15, 539–552.
Guindon, S. & Gascuel, O. (2003) A simple, fast and accurate method to estimate large phylogenies by maximum-likelihood. *Systematic Biology*, 52, 696–704.
Hebert, P.D.N., Cywinska, A., Ball, S.L. & deWaard, J.R. (2003) Biological identifications through DNA barcodes. *Proceedings of the Royal Society B: Biological Sciences*, 270 (1512), 313–321. http://dx.doi.org/10.1098/rspb.2002.2218
Hebert, P.D.N., Stoeckle, M.Y., Zemlak, T.S. & Francis, C.M. (2004) Identification of birds through DNA barcodes. *PLoS Biology*, 2, 1657–1663. http://dx.doi.org/10.1371/journal.pbio.0020312
Kehlmaier, C. (2002) Hoverflies (Diptera: Syrphidae) from northern Spain, with notes on *Pelecocera tricincta* Meigen, 1822. *Volucella*, 6, 139–153.
Kehlmaier, C. & Assmann, T. (2008) The European species of *Chalarus* Walker, 1834 revisited (Diptera: Pipunculidae). *Zootaxa*, 1936, 1–39.
Kehlmaier, C., Michalko, R. & Korenko, S. (2012) *Ogcodes fumatus* (Diptera: Acroceridae) reared from *Philodromus cespitum* (Araneae: Philodromidae), and first evidence of *Wolbachia* alphaproteobacteria in Acroceridae. *Annales Zoologici (Warszawa)*, 62 (2), 281–286. http://dx.doi.org/10.3161/000345412x652819
Kerr, P.H. & Winterton, S.L. (2008) Do parasitic flies attack mites? Evidence in Baltic amber. *Biological Journal of the Linnean Society*, 93, 9–13.
Langer, G. (2005) Ein seltener Parasitoid der Wolfspinne *Pardosa alacris* (Araneae: Lycosidae): *Ogcodes gibbosus* (Diptera: Acroceridae). *Arachnologische Mitteilungen*, 29, 45–48. http://dx.doi.org/10.5431/aramit2907
Larrivée, M. & Borkent, C.J. (2009) New spider host associations for three acrocerid fly species (Diptera, Acroceridae). *Journal of Arachnology*, 37, 241–242. http://dx.doi.org/10.1636/t08-62.1
Latreille, P.A. (1805) *Histoire naturelle, générale et particulière des crustacés et des insectes. Tome 14*. F. Dufart, Paris, 432 pp.
Majer, J. (1977) Data to the Acroceridae (Diptera) Fauna of Mongolia. *Folia Entomologica Hungarica Rovartani Közlemények (Series Nova)*, 30 (1), 105–107.
Meigen, J.W. (1804) *Klassifikazion und Beschreibung der europäischen zweiflügeligen Insekten (Diptera Linn.). Erster Band.* Reichard, Braunschweig, Abt. I, viii + 1–152 pp. Abt. II, vi + 153–314 pp.
Menge, A. (1866) Preussische Spinnen. 1. Abtheilung. *Schriften der Naturforschenden Gesellschaft in Danzig (Neue Folge)*, 1 (3–4), 51–152 + 28 plates.
Millot, J. (1938) Le développement et la biologie larvaire des Oncodides (= Cyrtidés), Diptères parasites d'araignées. *Bulletin de la Société zoologique de France*, 63, 162–181 + 183–197.
Nartshuk, E.P. (1982) Review of Acrocerid flies (Diptera, Acroceridae) of the fauna of USSR with descriptions a new genus and new species. *Entomologicheskoe Obozrenie*, 61 (2), 404–417. [in Russian; English translation in *Entomological Review*, 61 (2), 155–169]
Nartshuk, E.P. (1988) Acroceridae. *In*: Soós, Á. & Papp, L. (Eds.), *Catalogue of Palaearctic Diptera. Vol. 5*. Akadémiai Kiadó/Elsevier, Budapest & Amsterdam, pp. 186–196.
Nartshuk, E.P. (1997) 2.32. Family Acroceridae. *In*: Papp, L. & Darvas, B. (Eds.), *Manual of Palaearctic Diptera. Vol. 2*. Science Herald, Budapest, pp. 469–485.
Nartshuk, E.P. (2000) On synonymy of *Acrocera* Meigen and *Paracrocera* Mik (Diptera: Acroceridae). *Zoosystematica Rossica*, 8 (2) [1999], 300.
Nartshuk, E.P. (2013) Fauna Europaea: Acroceridae. *In*: Pape, T. & Beuk, P. (Eds.) *Fauna Europaea: Diptera: Brachycera.* Fauna Europaea version 2.6. Available from: http://www.faunaeur.org (accessed 25 February 2014)
Nielsen, E. (1932) *The biology of spiders, with special reference to the Danish fauna.* Levin & Munksgaard, Copenhagen, part I: 248 pp, part II: 723 pp.
Nielsen, B.O., Funch, P. & Toft, S. (1999) Self-injection of a Dipteran parasitoid into a Spider. *Naturwissenschaften*, 86, 530–532. http://dx.doi.org/10.1007/s001140050668
Nixon, K.C. & Carpenter, J.M. (1993) On outgroups. *Cladistics*, 9, 413–426. http://dx.doi.org/10.1111/j.1096-0031.1993.tb00234.x
Ottenheim, M.M., Waller, G.E. & Holloway, G.J. (1995) The influence of the development rates of immature stages of *Eristalis arbustorum* (Diptera; Syrphidae) on adult abdominal colour pattern. *Physiological Entomology*, 20, 343–348. http://dx.doi.org/10.1111/j.1365-3032.1995.tb00825.x
Panzer, G.W.F. (1803) *Fauna insectorum Germanicae initia, oder Deutschlands Insecten,* Heft 86. Felsecker, Nürnberg, 24 pp.

Posada, D. (2008) JMODELTEST: phylogenetic model averaging. *Molecular Biology and Evolution*, 25, 1253–1256. http://dx.doi.org/10.1093/molbev/msn083

Ralley, W.E. (1988) Oviposition behavior and the egg of *Acrocera orbicula* (Fab.) (Diptera: Acroceridae). *The Canadian Entomologist*, 120, 95–96. http://dx.doi.org/10.4039/ent12095-1

Ronquist, F. & Huelsenbeck, J.P. (2003) MRBAYES 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics*, 19, 1572–1574. http://dx.doi.org/10.1093/bioinformatics/btg180

Sabrosky, C.W. (1944) Revision of the American Spider Parasites of the Genera *Ogcodes* and *Acrocera* (Diptera, Acroceridae). *American Midland Naturalist*, 31 (2), 385–413. http://dx.doi.org/10.2307/2421075

Sack, P. (1936) 21. Cyrtidae (Acroceridae). *In*: Lindner, E. (Ed.), *Die Fliegen der paläarktischen Region, Band IV/1*. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 36 pp. + 3 plates.

Schlinger, E.I. (1965) Acroceridae. *In*: Stone, A., Sabrosky, C.W., Wirth, W.W., Foote, R.H. & Coulson, J.R., (Eds.), A Catalog of the Diptera of America north of Mexico. *United States Department of Agriculture, Agriculture Handbook 276*, 403–407.

Schlinger, E.I. (1987) The biology of Acroceridae (Diptera): true endoparasitoids of spiders. *In*: Nentwig, W. (Ed.), *Ecophysiology of Spiders*. Springer-Verlag, Berlin, pp. 319–327.

Schlinger, E.I. (2003) Acroceridae, spider-fly endoparasitoids. *In*: Goodman, M. & Benstead, J.P. (Eds.), *The Natural History of Madagascar*. University of Chicago Press, Chicago. pp. 734–740.

Schlinger, E.I., Gillung, J.P. & Borkent, C.J. (2013) New spider flies from the Neotropical Region (Diptera, Acroceridae) with a key to New World genera. *ZooKeys*, 270, 59–93. http://dx.doi.org/10.3897/zookeys.270.4476

Séguy, E. (1926) *Diptères (Brachycères). Faune de France,* 13, 308 pp.

Séguy, E. (1934) Diptères d'Espagne. Étude systématique basée principalement sur les collections formées par le R. P. Longin Navás, S. J. *Memorias de la Academia de Ciencias exactas, Físico-Químicas y Naturales de Zaragoza*, 3, 1–54.

Séguy, E (1956) Dipteres nouveaux ou peu connus d'Extreme-Orient. *Revue française d'entomologie*, 23, 174–178.

Sferra, N.J. (1986) The first record of *Pterodontia flavipes* Gray (Diptera: Acroceridae) larvae in the mites *Podothrombium* (Acari: Trombidiidae) and *Abrolophus* (Acari: Erythraeidae). *Entomological News*, 97, 121–123.

Skevington, J.H., Kehlmaier, C. & Ståhls, G. (2007) Molecular barcoding: Mixed results for Pipunculidae (Diptera). *Zootaxa*, 1423, 1–26.

Smith, M.A., Woodley, N.E., Janzen, D.H., Hallwachs, W. & Hebert, P.D.N. (2006) DNA barcodes reveal cryptic host-specificity within the presumed polyphagous members of a genus of parasitoid flies (Diptera: Tachinidae). *Proceedings of the National Academy of Sciences*, 103, 3657–3662. http://dx.doi.org/10.1073/pnas.0511318103

Stubbs, A. & Drake, M. (2001) *British soldierflies and their allies*. The British Entomological and Natural History Society, Reading, 512 pp.

Tamura, K., Peterson, D., Peterson, N., Stecher, G., Nei, M. & Kumar, S. (2011) MEGA5: Molecular Evolutionary Genetics Analysis using Maximum Likelihood, Evolutionary Distance, and Maximum Parsimony Methods. *Molecular Biology and Evolution*, 28, 2731–2739. http://dx.doi.org/10.1093/molbev/msr121

Toft, S., Nielsen, B.O. & Funch, P. (2012) Parasitoid suppression and life-history modifications in a wolf spider following infection by larvae of an acrocerid fly. *The Journal of Arachnology*, 40, 13–17. http://dx.doi.org/10.1636/p11-28.1

Trojan, P. (1956) *Oncodes reginae* sp. n. and notes on the European species of the family Cyrtidae (Diptera). *Annales Zoologici (Warszawa)*, 16 (8), 73–79.

Weinberg, M. (1966) Contribution to the knowledge of the Cyrtidae (Diptera) of Rumania. *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa"*, 5, 141–145.

Weinberg, M. (1984) New data on the presence and distribution of the Acroceridae (Diptera) in Romania. *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa"*, 26, 185–192.

Winterton, S.L. & Gillung, J.P. (2012) A new species of spider fly in the genus *Sabroskya* Schlinger from Malawi, with a key to Acrocerinae world genera (Diptera, Acroceridae). *ZooKeys*, 171, 1–15. http://dx.doi.org/10.3897/zookeys.171.2137

Winterton, S.L., Wiegmann, B.M. & Schlinger, E.I. (2007) Phylogeny and Bayesian divergence time estimations of small-headed flies (Diptera: Acroceridae) using multiple molecular markers. *Molecular Phylogenetics and Evolution*, 43, 808–832. http://dx.doi.org/10.1016/j.ympev.2006.08.015

Zetterstedt, J.W. (1838) *Dipterologis Scandinaviae. Sect. 3. Diptera. Insecta Lapponica.* Lipsiae [Leipzig], pp. 477–868.

Zimsen, E. (1964) *The type material of J. C. Fabricius*. Munksgaard, Copenhagen, 656 pp.