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## Review of the genus *Mansonella* Faust, 1929 *sensu lato* (Nematoda: Onchocercidae), with descriptions of a new subgenus and a new subspecies

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<sup>†</sup>In memory of our colleague Dr Odile Bain, who initiated this study and laid the ground work with her vast knowledge of the filarial worms and detailed morphological studies of the species presented in this paper

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## References

- Anderson, R.C. (2000) *Nematode Parasites of Vertebrates: Their Development and Transmission. Second Edition*. CAB International, Oxfordshire, 650 pp.
- Anderson, R.C. & Bain, O. (1976) Keys to genera of the order Spirurida. Part 3. Diplostriaenoidea, Aprocotoidea and Filarioidea, *In: Anderson, R.C., Chabaud, A.G. & Willmott, S. (Eds.), CIH Keys to the nematode parasites of vertebrates*. Archival Volume, 2009. CAB International, Oxfordshire, pp. 59–116.
- Bain, O. (2002) Evolutionary relationships among filarial nematodes. *In: Klei, T.R. & Rajan, T.V. (Eds.), World Class Parasites. The Filaria. Vol. 5*. Kluwer Academic Publishers, Boston, pp. 21–29.
- Bain, O., Dissanaïke, A.S., Cross, J.H., Harinasuta, C. & Sucharit, S. (1985) Morphologie de *Wuchereria bancrofti* adulte et sub-adulte. *Annales de Parasitologie Humaine et Comparée*, 60, 613–630.
- Bain, O., Mutafchiev, Y. & Junker, K. (2014) Order Spirurida. *In: Schmidt-Rhaesa, A. (Ed.), Handbook of Zoology. Gastrotricha, Cycloneuralia and Gnathifera. Volume 2. Nematoda*. De Gruyter, Berlin, pp. 661–732.
- Bain, O., Petit, G. & Rosales-Loesener, L. (1986) Filaires de singes sud-américains. *Bulletin du Muséum National d'Histoire Naturelle*, Section A, 3, 513–542.
- Bain, O., Moisson, P., Huerre, M., Landsoud-Soukate, J. & Tutin, C. (1995) Filariae from a wild gorilla in Gabon with description of a new species of *Mansonella*. *Parasite*, 2, 315–322.  
<http://dx.doi.org/10.1051/parasite/1995023315>
- Bartholomew, C.F., Nathan, M.B. & Tikasingh, E.S. (1978) The failure of diethylcarbamazine in the treatment of *Mansonella ozzardi* infections. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 72, 423–424.  
[http://dx.doi.org/10.1016/0035-9203\(78\)90141-4](http://dx.doi.org/10.1016/0035-9203(78)90141-4)
- Beaver, P.C., Neel, J.V. & Orihel, T.C. (1976) *Dipetalonema perstans* and *Mansonella ozzardi* in Indians of southern Venezuela. *American Journal of Tropical Medicine and Hygiene*, 25, 263–265.
- Casiraghi, M., Bordenstein, S.R., Baldo, L., Lo, N., Beninati, T., Wernegreen, J.J., Werren, J.H. & Bandi, C. (2005) Phylogeny of *Wolbachia pipientis* based on *gltA*, *groEL* and *ftsZ* gene sequences: clustering of arthropod and nematode symbionts in the F supergroup, and evidence for further diversity in the *Wolbachia* tree. *Microbiology*, 151, 4015–4022.  
<http://dx.doi.org/10.1099/mic.0.28313-0>
- Chabaud, A.G. & Bain, O. (1976) La lignée *Dipetalonema*. Nouvel essai de classification. *Annales de Parasitologie Humaine et Comparée*, 51, 365–397.
- Chabaud, A.G. & Bain, O. (1994) The evolutionary expansion of the Spirurida. *International Journal for Parasitology*, 24, 1179–1201.  
[http://dx.doi.org/10.1016/0020-7519\(94\)90190-2](http://dx.doi.org/10.1016/0020-7519(94)90190-2)
- Chabaud, A.G. & Petter, A.J. (1961) Remarques sur l'évolution des papilles cloacales chez les nématodes phasmidiens parasites de vertébrés. *Parassitologia*, 3, 51–70.
- Chadee, D.D., Rawlins, S.C., Doon, R. & Baboolal, S. (1994) Presence of annular rings on *Mansonella ozzardi* microfilariae. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 88, 356.  
[http://dx.doi.org/10.1016/0035-9203\(94\)90116-3](http://dx.doi.org/10.1016/0035-9203(94)90116-3)
- Chandler, A.C. (1929) Some new genera and species of nematode worms, Filarioidea, from animals dying in the Calcutta Zoological Gardens. *Proceedings of the United States National Museum*, 75, 1–10.
- Dunn, F.L. & Lambrecht, F.L. (1963) On some filarial parasites of South American primates, with a description of *Tetrapetalonema tamarinae* n. sp. from the Peruvian tamarin marmoset, *Tamarinus nigricollis* (Spix, 1823). *Journal of Helminthology*, 37, 261–286.  
<http://dx.doi.org/10.1017/S0022149X00019866>
- Eberhard, M.L. (1978) *Tetrapetalonema (T.) mystaxi* sp. n. (Nematoda: Filarioidea) from Brazilian moustached marmosets, *Sanguinus m. mystaxi*. *Journal of Parasitology*, 64, 204–207.  
<http://dx.doi.org/10.2307/3279657>
- Eberhard, M.L. & Orihel, T.C. (1984) The genus *Mansonella* (syn. *Tetrapetalonema*): a new classification. *Annales de Parasitologie Humaine et Comparée*, 59, 483–496.
- Eberhard, M.L., Campo-Aasen, I. & Orihel, T.C. (1984) *Mansonella (E.) rotundicapita* sp. n. and *Mansonella (E.) longicapita* sp. n. (Filarioidea: Onchocercidae) from Venezuelan capybaras, *Hydrochoerus hydrochaeris*. *Annales de Parasitologie Humaine et Comparée*, 59, 497–505.
- Esslinger, J.H. (1966) *Dipetalonema obtusa* (McCoy, 1936) comb. n. (Filarioidea: Onchocercidae) in Colombian primates, with a description of the adult. *Journal of Parasitology*, 52, 498–502.

- <http://dx.doi.org/10.2307/3276317>
- Esslinger, J.H. (1979) *Tetrapetalonema (T.) panamensis* (McCoy, 1936) comb. n. (Filarioidea: Onchocercidae) in Colombian primates, with a description of the adults. *Journal of Parasitology*, 65, 924–927.  
<http://dx.doi.org/10.2307/3280251>
- Esslinger, J.H. (1981) *Tetrapetalonema (T.) saimiri* sp. n. (Nematoda: Filarioidea) from Colombian squirrel monkeys, *Saimiri sciureus*. *Journal of Parasitology*, 67, 268–271.  
<http://dx.doi.org/10.2307/3280648>
- Esslinger, J.H. (1982) *Tetrapetalonema (T.) colombiensis* sp. n. (Nematoda: Filarioidea) from Colombian primates. *Journal of Parasitology*, 68, 1138–1141.  
<http://dx.doi.org/10.2307/3281106>
- Esslinger, J.H. & Gardiner, C.H. (1974) *Dipetalonema barbascalensis* sp. n. (Nematoda: Filarioidea) from the owl monkey, *Aotus trivirgatus*, with a consideration of the status of *Parlitomosa zakii* Nagaty, 1935. *Journal of Parasitology*, 60, 1001–1005.  
<http://dx.doi.org/10.2307/3278536>
- Faust, E.C. (1935) Notes on the helminths of Panama. III.-Filarial infection in the marmosets, *Leontocebus geoffroyi* (Pucheran) and *Saimiri orstedii orstedii* (Reinhardt) in Panama. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 28, 627–634.  
[http://dx.doi.org/10.1016/S0035-9203\(35\)90033-5](http://dx.doi.org/10.1016/S0035-9203(35)90033-5)
- Ferri, E., Bain, O., Martin, C., Lo, N., Uni, S., Landmann, F., Baccei, S.G., Guerrero, R., de Souza Lima, S., Bandi, C., Wanji, S., Diagne, M. & Casiraghi, M. (2011) New insights into the evolution of *Wolbachia* infections in filarial nematodes, inferred from a large range of screened species. *PLoS One*, 6, e20843.  
<http://dx.doi.org/10.1371/journal.pone.0020843>
- Ferri, E., Barbuto, M., Bain, O., Galimberti, A., Uni, S., Guerrero, R., Ferté, H., Bandi, C., Martin, C. & Casiraghi, M. (2009) Integrated taxonomy: traditional approach and DNA barcoding for the identification of filarioid worms and related parasites (Nematoda). *Frontiers in Zoology*, 6, 1–12.  
<http://dx.doi.org/10.1186/1742-9994-6-1>
- Fischer, A., Bamuhigab, J. & Büttner, D.W. (1997) Occurrence and diagnosis of *Mansonella streptocerca* in Uganda. *Acta Tropica*, 63, 43–55.  
[http://dx.doi.org/10.1016/S0001-706X\(96\)00607-9](http://dx.doi.org/10.1016/S0001-706X(96)00607-9)
- Godoy, G.A., Orihel, T.C. & Volcan, G.S. (1980) *Microfilaria bolivarensis*: a new species of filaria from man in Venezuela. *American Journal of Tropical Medicine and Hygiene*, 29, 545–547.
- Keiser, P.B., Coulibaly, Y., Kubofcik, J., Diallo, A.A., Klion, A.D., Traore, S.F. & Nutman, T.B. (2008) Molecular identification of *Wolbachia* from the filarial nematode *Mansonella perstans*. *Molecular and Biochemical Parasitology*, 160, 123–128.  
<http://dx.doi.org/10.1016/j.molbiopara.2008.04.012>
- Kim, J.C.S. & Wolf, R.J. (1980) Diseases of moustached marmosets. In: Montali, R.J. & Migaki, R.G. (Eds.), *The Comparative Pathology of Zoo Animals. Proceedings of a Symposium Held at the National Zoological Park, Smithsonian Institution, October 2-4, 1978*. Smithsonian Institution Press, Washington, pp. 431–435.
- Kozek, W.J., Palma, G., Henao, A., Garcia, H. & Hoyos, M. (1983) Filariasis in Colombia: prevalence and distribution of *Mansonella ozzardi* and *Mansonella* (= *Dipetalonema*) *perstans* infections in the Comisaria del Guainia. *American Journal of Tropical Medicine and Hygiene*, 32, 379–384.
- Lefoulon, E., Gavotte, L., Junker, K., Barbuto, M., Uni, S., Landmann, F., Laaksonen, S., Saari, S., Nikander, S., de Souza Lima, S., Casiraghi, M., Bain, O. & Martin, C. (2012) A new type F *Wolbachia* from Splendidofilariinae (Onchocercidae) supports the recent emergence of this supergroup. *International Journal for Parasitology*, 42, 1025–1036.  
<http://dx.doi.org/10.1016/j.ijpara.2012.09.004>
- Lo, N., Casiraghi, M., Salati, E., Bazzocchi, C. & Bandi, C. (2002) How many *Wolbachia* supergroups exist? *Molecular Biology and Evolution*, 19, 341–346.  
<http://dx.doi.org/10.1093/oxfordjournals.molbev.a004087>
- Marcos, L.A., Arrospide, N., Recuenco, S., Cabezas, C., Weil, G.J. & Fischer, P.U. (2012) Genetic characterization of atypical *Mansonella* (*Mansonella*) *ozzardi* microfilariae in human blood samples from northeastern Peru. *American Journal of Tropical Medicine and Hygiene*, 87, 491–494.  
<http://dx.doi.org/10.4269/ajtmh.2012.11-0379>
- McCoy, O.R. (1936) Filarial parasites of the monkeys of Panama. *American Journal of Tropical Medicine and Hygiene*, 16, 383–403.
- Morales-Hojas, R., Post, R.J., Shelley, A.J., Maia-Herzog, M., Coscaron, S. & Cheke, R. (2001) Characterisation of nuclear ribosomal DNA sequences from *Onchocerca volvulus* and *Mansonella ozzardi* (Nematoda: Filarioidea) and development of a PCR-based method for their detection in skin biopsies. *International Journal for Parasitology*, 31, 169–177.  
[http://dx.doi.org/10.1016/S0020-7519\(00\)00156-9](http://dx.doi.org/10.1016/S0020-7519(00)00156-9)
- Mootnick, A. & Groves, C.P. (2005) A new generic name for the hoolock gibbon (Hylobatidae). *International Journal of Primatology*, 26, 971–976.  
<http://dx.doi.org/10.1007/s10764-005-5332-4>

- Mullin, S.W. & Orihel, T.C. (1972) *Tetrapetalonema dunni* sp. n. (Nematoda: Filarioidea) from Malaysian tree shrews. *Journal of Parasitology*, 58, 1047–1051.  
<http://dx.doi.org/10.2307/3278131>
- Nagaty, H.F. (1935) *Parlitomosa zakii* (Filariinae), a new genus and species and its microfilaria from *Leontocebus rosalia*. *Journal of the Egyptian Medical Association*, 18, 483–496.
- Neafie, R.C., Connor, D.H. & Meyers, W.M. (1975) *Dipetalonema streptocerca* (Macfie and Corson, 1922): description of the adult female. *American Journal of Tropical Medicine and Hygiene*, 24, 264–267.
- Nelson, G.S. (1965) Filarial infections as zoonoses. *Journal of Helminthology*, 39, 229–250.  
<http://dx.doi.org/10.1017/S0022149X00020630>
- Orihel, T.C. (1967) Infections with *Dipetalonema perstans* and *Mansonella ozzardi* in the aboriginal Indians of Guyana. *American Journal of Tropical Medicine and Hygiene*, 16, 628–635.
- Orihel, T.C. & Eberhard, M.L. (1982) *Mansonella ozzardi*: a redescription with comments on its taxonomic relationships. *American Journal of Tropical Medicine and Hygiene*, 31, 1142–1147.
- Peel, E. & Chardome, M. (1946) Sur des Filaridés des Chimpanzés *Pan paniscus* et *Pan satyrus* au Congo Belge. *Annales de la Société Belge de Médecine Tropicale*, 26, 117–156.
- Peel, E. & Chardome, M. (1947) Note complémentaire sur des filaridés de chimpanzés *Pan paniscus* et *Pan satyrus* au Congo belge. *Annales de la Société Belge de Médecine Tropicale*, 27, 241–250.
- Petit, G., Bain, O. & Roussillon, C. (1985) Deux nouvelles filaires chez un singe, *Saimiri sciureus*, au Guyana. *Annales de Parasitologie Humaine et Comparée*, 60, 65–81.
- Price, D.L. (1962) Description of *Dipetalonema interstitium* n. sp. from the grey squirrel and *Dipetalonema llewellyni* n. sp. from the racoon. *Proceedings of the Helminthological Society of Washington*, 29, 77–82.
- Raccurt, C., Lowrie, R.C. Jr. & McNeeley, D.F. (1980) *Mansonella ozzardi* in Haiti. I. Epidemiological survey. *American Journal of Tropical Medicine and Hygiene*, 29, 803–808.
- Reichenow, E. (1917) Parasites of the blood and intestine of African anthropoid apes. Madrid, *Boletín de la Real Sociedad Española de Historia Natural, Madrid*, 17, 312–332.
- Sandground, J.H. (1933) Report on the nematode parasites collected by the Kelley-Roosevelts expedition to Indo-China with descriptions of several new species. Part 1. Parasites of birds. Part 2. Parasites of mammals. *Zeitschrift für Parasitenkunde*, 5, 542–583.  
<http://dx.doi.org/10.1007/BF02121363>
- Schmidt, L.H. & Esslinger, J.H. (1981) Courses of infections with *Plasmodium falciparum* in owl monkeys displaying a microfilaremia. *American Journal of Tropical Medicine and Hygiene*, 30, 5–11.
- Shelley, A.J. & Coscarón, S. (2001) Simuliid blackflies (Diptera: Simuliidae) and ceratopogonid midges (Diptera: Ceratopogonidae) as vectors of *Mansonella ozzardi* (Nematoda: Onchocercidae) in Northern Argentina. *Memórias do Instituto Oswaldo Cruz*, 96, 451–458.  
<http://dx.doi.org/10.1590/S0074-02762001000400003>
- Simonsen, P.E., Onapa, A.W. & Asio, S.M. (2011) *Mansonella perstans* filariasis in Africa. *Acta Tropica*, 120 (Supplement 1), 109–120.  
<http://dx.doi.org/10.1016/j.actatropica.2010.01.014>
- Sousa, O.E., Rossan, R.N. & Baerg, D.C. (1974) The prevalence of trypanosomes and microfilariae in Panamanian monkeys. *American Journal of Tropical Medicine and Hygiene*, 23, 862–868.
- Uni, S. (1983) Filarial parasites from the black bear of Japan. *Annales de Parasitologie Humaine et Comparée*, 58, 71–84.
- Uni, S., Suzuki, Y., Baba, M., Mitani, N., Takaoka, H., Katsumi, A. & Bain, O. (2001) Coexistence of five *Cercopithifilaria* species in the Japanese rupicaprine bovid, *Capricornis crispus*. *Parasite*, 8, 197–213.  
<http://dx.doi.org/10.1051/parasite/2001083197>
- Uni, S., Bain, O. & Takaoka, H. (2004) Affinities between *Cutifilaria* (Nematoda: Filarioidea), parasites of deer, and *Mansonella* as seen in a new onchocercid, *M. (C.) perforata* n. sp. from Japan. *Parasite*, 11, 131–140.  
<http://dx.doi.org/10.1051/parasite/2004112131>
- Van den Berghe, L. & Chardome, M. (1949) Une microfilaire du gorille, *Microfilaria gorilla*. *Annales de la Société Belge de Médecine Tropicale*, 29, 495–500.
- Van den Berghe, L., Chardome, M. & Peel, E. (1964) The filarial parasites of the eastern gorilla in the Congo. *Journal of Helminthology*, 38, 349–368.  
<http://dx.doi.org/10.1017/S0022149X00033903>
- Webber, W.A.F. & Hawking, F. (1955) The filarial worms *Dipetalonema digitatum* and *D. gracile* in monkeys. *Parasitology*, 45, 401–408.  
<http://dx.doi.org/10.1017/S0031182000027736>
- Wilson, D.E. & Reeder, D.A. (Eds.) (2005) *Mammal Species of the World. A Taxonomic and Geographic Reference. Third Edition*. Johns Hopkins University Press, Baltimore, Maryland, 2142 pp.
- Yamaguti, S. (1941) Studies on the helminth fauna of Japan. Part 35. Mammalian nematodes II. *Japanese Journal of Zoology*, 9, 409–439.
- Yates, J.A. & Hellner, K.L. (1989) Filariasis in Colombian capybaras: circadian and spatial distributions of microfilariae in the skin. *Proceedings of the Helminthological Society of Washington*, 56, 24–28.