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Collembola of Rapa Nui (Easter Island) with descriptions of five endemic cave-restricted species

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Abstract

Eight species of Collembola are reported from recent collections made in caves on the Polynesian island of Rapa Nui (Easter Island). Five of these species are new to science and apparently endemic to the island: *Coecobrya aitorererere* n. sp., *Cyphoderus manuneru* n. sp., *Entomobrya manuhoko* n. sp., *Pseudosinella hahoteana* n. sp. and *Seira manukio* n. sp. The Hawaiian species *Lepidocyrtus olena* Christiansen & Bellinger and the cosmopolitan species *Folsomia candida* Willem also were collected from one or more caves. *Coecobrya kennethi* Jordana & Baquero, recently described from Rapa Nui and identified as endemic, was collected in sympatric association with *C. aitorererere* n.sp. With the exception of *F. candida*, all species are endemic to Rapa Nui or greater Polynesia and appear to be restricted to the cave environment on Rapa Nui. A key is provided to separate Collembola species reported from Rapa Nui. We provide recommendations to aid in the conservation and management of these new Collembola, as well as the other presumed cave-restricted arthropods.

Key words: Chaetotaxy, taxonomy, key to species, Entomobryidae, Isotomidae, Paronellidae

Introduction

Due to a number of environmental factors including geographic isolation, island size and low topographic relief (see Rolett & Diamond 2004), Rapa Nui (Easter Island) was predisposed to dramatic human-induced environmental change. Following Polynesian colonization (800–1200 CE; Hunt & Lipo 2006, Shepardson *et al.* 2008) and sometime before European contact in 1722 (McCall 1990), a catastrophic ecological shift occurred where the palm-dominated shrubland was ultimately replaced by grassland (Wynne *et al.* 2014). By the mid-nineteenth century (several hundred years later), nearly the entire island was converted into a century-long sheep-grazing operation (Fischer 2005). These human activities resulted in the loss of most stands of native vegetation and the extinction of all terrestrial vertebrates.

The arthropod fauna of Rapa Nui was similarly impacted. Over the past four decades, entomologists have commented on the impoverished native arthropod communities and the proliferation of nonnative invasive arthropod species (Kuschel 1963, Campos & Peña 1973, Desender & Baert 1997). Prior to fieldwork conducted by the third author, of the nearly 400 arthropod species known to the island, only 20 species (~5%) were identified as either endemic or indigenous; the remaining arthropods were intentionally or accidentally introduced to the island (J.J. Wynne, unpublished data).

There have been some efforts to assess Rapa Nui microarthropods (e.g., Hammer 1970, Mockford 1972), but Collembola have scarcely been studied. Schött (1921) recorded a single specimen of *Entomobrya multifasciata* (Tullberg, 1871). This record apparently was the source used by Kuschel (1963) to indicate a single species of Collembola from Rapa Nui, but he did not provide a scientific name or attribution to Schött's paper. The list of arthropod species provided by Campos & Peña (1973) also included a single unnamed species, which attributed the

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Literature cited

- Barra, J.-A. (2004) Le genre *Seira* (Collembola, Entomobryidae) du Yémen continental. *Zoosystema*, 26, 291–306.
- Bellini, B.C. & Zeppelini, D. (2008) Three new species of *Seira* Lubbock (Collembola, Entomobryidae) from Mataraca, Paraíba, Brazil. *Zootaxa*, 1773, 44–54.
- Campos, S.L. & Peña, G.E.L. (1973) Los insectos de Isla de Pascua. *Revista Chilena de Entomología*, 7, 217–229.
- Chen, J.-X. & Christiansen, K. (1997) Subgenus *Coecobrya* of the genus *Sinella* (Collembola: Entomobryidae) with special reference to the species of China. *Annals of the Entomological Society of America*, 90, 1–19.
<http://dx.doi.org/10.1093/aesa/90.1.1>
- Chown, S.L., Slabber, S., McGeoch, M.A., Janion, C. & Leinaas, H.P. (2007) Phenotypic plasticity mediates climate change responses among invasive and indigenous arthropods. *Proceedings of the Royal Society B*, 274, 2531–2537.
<http://dx.doi.org/10.1098/rspb.2007.0772>
- Christiansen, K. (1963) Preliminary notes on the genus *Entomobrya* in South America with special reference to Patagonia. *Biologie de l'Amérique Australe*, 2, 149–159.
- Christiansen, K. & Bellinger, P. (1992) Collembola. *Insects of Hawaii*, 15, 1–445.
- Christiansen, K. & Bellinger, P. (1996) Cave *Pseudosinella* and *Oncopodura* new to science. *Journal of Cave and Karst Studies*, 58, 38–53.
- Christiansen, K. & Bellinger, P. (1998) Marine littoral Collembola of North and Central America. *Bulletin of Marine Science*, 42, 215–245.
- Christiansen, K. & Bellinger, P. (2000) A survey of the genus *Seira* (Hexapoda: Collembola: Entomobryidae) in the Americas. *Caribbean Journal of Science*, 36, 39–75.
- Chu, P.-S., Chen, Y.R. & Schroeder, T.A. (2010) Changes in precipitation extremes in the Hawaiian Islands in a warming climate. *Journal of Climate*, 23, 4881–4900.
<http://dx.doi.org/10.1175/2010JCLI3484.1>
- Delamare Deboutteville, C. (1948) Recherches sur les Collembolites termitophiles et myrmécophiles. *Archives de Zoologie Expérimentale et Générale*, 85, 261–425.
- Denis, J.R. (1924) Sur les Collembolites du Muséum de Paris (1er Partie). *Annales de la Société Entomologique de France*, 93, 211–260.
- Desender, K. & Baert, L. (1997) Conservation of terrestrial arthropods on Easter Island as exemplified by the beetle fauna. *Conservation Biology*, 11, 836–838.
- Fischer, S.R. (1994) Rapanui's "great old words": E timo te akoako. *The Journal of the Polynesian Society*, 103, 413–443.
- Fischer, S.R. (2005) *Island at the end of the world: The turbulent history of Easter Island*. Reaktion Books, London, 304 pp.
- Fjellberg, A. (1998) The labial palp in Collembola. *Zoologische Anzeiger*, 237, 309–330.
- Folsom, J.W. (1927) Insects of the Subclass Apterygota from Central America and the West Indies. *Proceedings of the U. S. Natural History Museum*, 72, 1–16.
<http://dx.doi.org/10.5479/si.00963801.72-2702.1>
- Folsom, J.W. (1932) Hawaiian Collembola. *Proceedings of the Hawaiian Entomological Society*, 8, 51–80.
- Fordham, D.A. & Brook, B.W. (2010) Why tropical island endemics are acutely susceptible to global change. *Biodiversity and Conservation*, 19, 329–342.
<http://dx.doi.org/10.1007/s10531-008-9529-7>
- Fortin, M. (2009) The development of theatre in Easter Island. Hakararama I Te A'amū O Rapa Nui. Unpublished M.A. thesis, University of Otago, Dunedin, 211 pp. [New Zealand]
- Gama, M.M. (1974) Systématique évolutive des *Pseudosinella*. X. Espèces provenant de Yougoslavie, de Bulgarie et des Iles Canaries (Insecta: Collembola). *Revue Suisse de Zoologie*, 81, 551–559.
- Hammer, M. (1970) A few oribatid mites from Easter Island. *Pacific Insects*, 12, 279–289.
- Handschin, E. (1927) Collembolites aus Costa Rica. *Entomologische Mitteilungen*, 16, 110–118.
- Howarth, F.G. (1982) Bioclimatic and geologic factors governing the evolution and distribution of Hawaiian cave insects. *Entomologia Generalis*, 8, 17–26.
- Hunt, T. & Lipo, C. (2006) Late colonisation of Easter Island. *Science*, 311, 1603–1606.
<http://dx.doi.org/10.1126/science.1121879>
- [IPCC] Intergovernmental Panel on Climate Change (2013) Climate Change 2013: The physical science basis. Available from: <http://www.ipcc.ch/report/ar5/wg1/> (accessed 31 January 2015)
- Jacquemart, S. (1976) XXII.- Collembolites nouveaux des Iles Galapagos. *Mission zoologique belge aux îles Galapagos et en Ecuador (N. et J. Leleup, 1964-1965)*, 3, 137–157.
- Jacquemart, S. (1980) Collembolites entomobryens nouveaux d'Afrique central. *Bulletin de l'Institut Royal des Sciences*

- Jantarit, S., Satasook, C. & Deharveng, L. (2014) *Cyphoderus* (Cyphoderidae) as a major component of collembolan cave fauna in Thailand, with description of two new species. *ZooKeys*, 368, 1–21.
<http://dx.doi.org/10.3897/zookeys.368.6393>
- Jordana, R. (2012) Synopses on Palaearctic Collembola: Capbryinae & Entomobryini. *Soil Organisms*, 84, 1–390.
- Jordana, R. & Baquero, E. (2005) A proposal of characters for taxonomic identification of *Entomobrya* species (Collembola, Entomobryomorpha), with description of a new species. *Abhandlungen und Berichte des Naturkundemuseums, Görlitz*, 76, 117–134.
- Jordana, R. & Baquero, E. (2008) *Coecobrya kennethi* n. sp. (Collembola, Entomobryomorpha) and presence of *Arrhopalites caecus* (Tullberg, 1871) from Ana Roiho cave (Maunga Hiva Hiva), Rapa Nui-Easter Island. *Euryale*, 2, 68–75.
- Kuschel, G. (1963) Composition and relationship of the terrestrial faunas of Easter, Juan Fernandez, Desventuradas, and Galapagos Islands. *California Academy of Sciences, Occasional Papers*, 44, 79–95.
- McCall, G. (1990) Rapanui and outsiders: The early days. In: Illius, B. & Barthel, T.S (Eds.), *Circumpacifica; Festschrift für Thomas S. Barthel*. Lang, Frankfurt am Main, pp. 165–225. [Germany]
- Mari Mutt, J.A. (1986) Puerto Rican species of *Lepidocyrtus* and *Pseudosinella* (Collembola: Entomobryidae). *Caribbean Journal of Science*, 22, 1–48.
- Mockford, E.L. (1972) Psocoptera records from Easter Island. *Proceedings of the Entomological Society of Washington*, 74, 327–329.
- Mockford, E.L. & Wynne, J.J. (2013) Genus *Cyptophania* Banks (Psocodea: Lepidopsocidae): Unique features, augmented description of the genotype, and descriptions of three new species. *Zootaxa*, 3702 (5), 437–449.
<http://dx.doi.org/10.11646/zootaxa.3702.5.3>
- Northup, D.E. & Welbourn, W.C. (1997) Life in the twilight zone—lava tube ecology, natural history of El Malpais National Monument. *New Mexico Bureau of Mines and Mineral Resources Bulletin*, 156, 69–82.
- Packard, A.S. (1873) Synopsis of the Thysanura of Essex County, Mass., with description of a few extralimital forms. *Report of the Peabody Academy*, 5, 23–51.
- Potapov, M. & Yan, G. (2012) *Folsomia* of China I – *fimetaria* group (Collembola: Isotomidae). *Annales de la Société Entomologique de France, Nouvelle Série*, 48, 51–56.
<http://dx.doi.org/10.1080/00379271.2012.10697750>
- Rapoport, E.H. (1962) Colembolos de Bahia Blanca (Argentina) III. *Publicaciones del Instituto de Edafología e Hidrología*, No. 2, 3–24.
- Rolett, B. & Diamond, J. (2004) Environmental predictors of pre-European deforestation on Pacific Islands. *Nature*, 431, 443–446.
<http://dx.doi.org/10.1038/nature02801>
- Routledge, K. (2007) The mysteries of Easter Island: the story of an expedition (Reprint of original 1919 edition). Cosimo, New York, 568 pp.
- Rusek, J. (1971) Zweiter Beitrag zur Kenntnis der Collembola (Apterygota) Chinas. *Acta Entomologica Bohemoslovaca*, 68, 108–137.
- Schäffer, C. (1897) Hamburger magalhänische Sammelreise, Apterygoten, 8, 1–48.
- Schött, H. (1896) North American Apterygogenea. *Proceeding of the California Academy of Science*, 6, 169–196.
- Schött, H. (1921) Collembola aus den Juan Fernandez-Inseln und der Osterinsel. In: Skottsberg, C. (Ed.), *The natural history of Juan Fernandez and Easter Island*, III, pp. 33–39.
- Shepardson, B., Shepardson, D., Shepardson, F., Chui, S. & Graves, M. (2008) Re-examining the evidence for late colonisation on Easter Island. *Rapa Nui Journal*, 22, 97–101.
- Soto-Adames, F.N. (2008) Postembryonic development of the dorsal chaetotaxy in *Seira dowlingi* (Collembola, Entomobryidae); with an analysis of the diagnostic and phylogenetic significance of primary chaetotaxy in *Seira*. *Zootaxa*, 1683, 1–31.
- Soto-Adames, F.N. & Giordano, R. (2011) New species of springtails in the *Proisotoma* genus complex from Vermont and New York, USA with descriptive notes on *Ballistura alpa* Christiansen & Bellinger 1980 (Hexapoda, Collembola, Isotomidae). *Zookeys*, 147, 19–37.
<http://dx.doi.org/10.3897/zookeys.147.2093>
- Soto-Adames F.N. & Taylor, J.T. (2013) Chaetotaxy and character evolution in *Trogolaphysa* (Collembola, Entomobryoidea, Paronellidae), with descriptions of two new species from caves in Belize. *Zookeys*, 323, 35–74.
<http://dx.doi.org/10.3897/zookeys.323.4950>
- Szeptycki, A. (1979) *Chaetotaxy of the Entomobryidae and its phylogenetical significance. Morpho-systematic studies of Collembola, IV*. Polska Akademia Nauk, Zaklad Zoologii Systematycznej Doswiadczalnej, 219 pp.
- Tilman, D., May, R.M., Lehman, C.L. & Nowak, M.A. (1994) Habitat destruction and the extinction debt. *Nature*, 371, 65–66.
<http://dx.doi.org/10.1038/371065a0>
- Tullberg, T. (1871) Förteckning öfver svenska Podurider. *Öfversigt af Kongliga Vetenskaps-Akademiens Förhandlingar*, 28, 143–155.
- Vitousek, P.M., D'Antonio, C.M., Loope, L.L., Rejmánek, M. & Westbrooks, R. (1997) Introduced species: A significant component of human-caused global change. *New Zealand Journal of Ecology*, 21, 1–16.

- Wray, D.L. 1953. Some new species of springtail insects (Collembola). *Occasional Papers, Nature Notes, Raleigh North Carolina*, 1, 1–7.
- Wynne, J.J. (2013) Inventory, conservation and management of lava tube caves at El Malpais National Monument. *Park Science*, 34, 45–55.
- Wynne, J.J., Bernard, E.C., Howarth, F.G., Sommer, S., Soto-Adames, F.N., Taiti, S., Mockford, E.L., Horrocks, M., Pakarati, L. & Pakarati-Hotus, V. (2014) Disturbance relicts in a rapidly changing world: The Rapa Nui (Easter Island) factor. *Bioscience*, 64, 711–718.
<http://dx.doi.org/10.1093/biosci/biu090>
- Zhang, F., Deharveng, L. & Chen, J.-X. (2009) New species and rediagnosis of *Coecobrya* (Collembola: Entomobryidae), with a key to the species of the genus. *Journal of Natural History*, 43, 2597–2615.
<http://dx.doi.org/10.1080/00222930903243970>
- Zhang, F., Yu, D. & Xu, G. (2011) Transformational homology of the tergal setae during postembryonic development in the *Sinella-Coecobrya* group (Collembola: Entomobryidae). *Contributions to Zoology*, 80, 213–230.