



<http://dx.doi.org/10.11646/zootaxa.3790.4.7>

<http://zoobank.org/urn:lsid:zoobank.org:pub:8179D8F9-A776-448E-9503-4D1CAD8692F2>

Redescription of '*Polyzonium*' *malagassum*, a new synonym of *Rhinotus purpureus* (Pocock, 1894), with notes about the occurrence of the order Polyzoniida on Madagascar (Diplopoda)

THOMAS WESENER

Zoologisches Forschungsmuseum Alexander Koenig, Leibniz Institute for Animal Biodiversity, Center for Taxonomy and Evolutionary Research (Section Myriapoda), Adenauerallee 160, 53113 Bonn, Germany. E-Mail: t.wesener@zfmk.de

Abstract

Polyzonium malagassum de Saussure & Zehntner, 1902, the only indigenous record of the order Polyzoniida from Madagascar, is redescribed after a study of the type specimens. The only male specimen is selected as the lectotype and illustrated. *P. malagassum* is discovered to be a synonym of the widespread tropical tramp species *Rhinotus purpureus* (Pocock, 1894). A mapping of additional locality data of *R. purpureus* shows that the species is widespread in Malagasy rainforests and montane rainforests, and occurs locally in high densities. Seven potentially indigenous Polyzoniida morphospecies also occur on Madagascar, but these undescribed species are more localized and show a lower abundance than *R. purpureus*. Brief notes, locality data, and Museum acronyms are given for the undescribed Polyzoniida species, which will hopefully assist future studies on Malagasy representatives of this little-known but biogeographically interesting order. With the discovery of the ubiquitous presence of *R. purpureus* on Madagascar, the similarity of the defense secretions of South American and of endemic Malagasy poison dart frogs (family Mantellidae) might derive from the fact that both groups prey on and sequester alkaloids from the same species of millipede.

Key words: Millipede, invasive, Mantellidae, dietary sequestration, alkaloid occurrence

Introduction

The order Polyzoniida, belonging to the 'beaked' millipedes of the superorder Colobognatha (Blanke & Wesener 2014), are with more than 70 described species one of the smaller and neglected orders of the 12,000 described species in the class Diplopoda. The order is distributed worldwide, with a conspicuous absence from all of Africa except South Africa and Madagascar (Shelley & Golovatch 2011). In Africa, only one of the three families of the Polyzoniida, the Siphonotidae, are known to occur. From South Africa three genera, *Cylichmogaster*, *Burinia*, and *Rhynchomecogaster* are known (Verhoeff 1937; Attems 1926), with *Cylichmogaster* being the only member of the whole superorder Colobognatha capable of limited volvation, which means rolling into a ball. The three genera are highly distinct, but in need of a modern revision. While recent inventories saw a large increase of the number of millipede genera and species known from Madagascar, this increase is currently limited to the Chordeumatida (Mauriès 1994; 1997), Sphaerotheriida (Wesener 2009; Wesener *et al.* 2010) and Spirobolida (Wesener *et al.* 2009; Wesener *et al.* 2011). Records of the order Polyzoniida from Madagascar are limited to one indigenous record, '*Polyzonium*' *malagassum* de Saussure & Zehntner, 1902, known only from its first description. *Polyzonium* is a chiefly European genus (Kime & Enghoff 2011), but a century ago it was a common genus name for all representatives of the Polyzoniida. The first description was quite comprehensive, even for modern times, but the species was never revised, and the gonopods of the male never illustrated.

Further records of the Polyzoniida on Madagascar concern the widespread tropical tramp species *Rhinotus purpureus* (Attems 1910, originally described as *Orsilochus acuticonus* Attems, but synonymized under *R. purpureus* by Golovatch & Korsos 1992). A natural occurrence (or absence) of the order Polyzoniida on Madagascar is not only important in view of future systematic or biogeographic analyses of the order (Shelley & Golovatch 2011), but also for a better understanding of the apparently convergent evolution of defense secretions in

Discussion

Polyzoniida are restricted to the humid forests on Madagascar. No specimen records exist from the spiny forest or dry forest ecosystem. With the synonymization of *P. malagassum* under *R. purpureus* no name is available for the potentially indigenous Polyzoniida on Madagascar. *R. purpureus* is widespread throughout Madagascar (Fig. 3) and data from 12 localities exists. Its occurrence in several montane forests far away from human plantations suggests an active spread of the invasive *R. purpureus* throughout the rainforests of Madagascar. Locally, *R. purpureus* is very common, and indeed far more common than the sympatrically occurring potentially indigenous species. Furthermore, the non-*Rhinotus* polyzoniid species seem to be locally restricted, with differently sized and coloured specimens found at the different sites. It is currently unclear if the invasive *R. purpureus* replaces the indigenous Malagasy Polyzoniida. The sympatric occurrence of both introduced and indigenous species in the same forest might speak against such replacement, while the much higher abundance of *R. purpureus* at the sites might be an argument that a replacement occurs. The occurrences of seven morphospecies of potential indigenous Polyzoniida, each from a distinct locality, show that the order is an important part of the millipede fauna on Madagascar.

***Rhinotus* and the convergent evolution of defense secretions in poison frogs on Madagascar and in South America:** Previous studies found a surprising similarity in some of the chemical components, all alkaloids, present in poison dart frogs from Madagascar and South America (Clark *et al.* 2005). Both groups of frogs sequester the chemicals from their arthropod prey. It is therefore not surprising that the mobile and active (and locally very abundant) *Rhinotus* millipedes are a potential part of the diet of the small frogs of the endemic family Mantellidae (Clark *et al.* 2005). Millipedes of the order Polyzoniida in general (Meinwald *et al.* 1975; Röper 1978; Wood *et al.* 2000), and especially *R. purpureus* (Saporito *et al.* 2003) are known producers of a variety of alkaloids found also in frog skins, such as polyzonimine and nitropolyzonimine. While evidence for the frogs preying on *R. purpureus* is mostly circumstantial, spiropyrolizidine alkaloids are only found in *R. purpureus* and not in other potential prey items of poison-dart frogs. We therefore have the curious instance that unrelated poison dart frogs from South America and Madagascar potentially feed on the same species of millipede, *R. purpureus*, to produce the same or very similar defense secretions.

Acknowledgements

Many thanks to Jean-Jacques Geoffroy (MNHN) for loaning out the valuable type series of *P. malagassum* and giving permission to conduct dissections. Thorsten Klug (ZFMK) assisted in the dissection of the tiny specimens and prepared the multi-layer illustrations. Peter Schwendinger (MHNG) graciously hosted the author during a visit in 2012, as well as arranged several loans. The editor Bill Shear and anonymous reviewers thankfully improved the quality of the work presented here, while Holly E. Wesener corrected the English of the manuscript. Much of the data was collected during a visit to the CAS in 2005 hosted by Charles Griswold and Darrel Ubick, whose help is greatly appreciated. Steve Goodman (FMNH) helped in identifying some Malagasy localities. The Field Museum material was sorted during a visit to the Field Museum which was financed by a travel grant of the ‘Studienstiftung des Deutschen Volkes’ in 2006, as well as PEET (NSF grant DEB 05–29715).

References

- Attems, C. (1910) Myriopoden von Madagaskar, den Comoren und den Inseln Ostafrikas. *Voeltzkow, A., Reise in Ostafrika in den Jahren 1903–1905. Wissenschaftliche Ergebnisse, Systematische Arbeiten*, 3, 73–115.
- Attems, C. (1926–1930) Myriapoda. *In: Kükenthal- Krumbach (Eds.), Handbuch der Zoologie*, Walter de Gruyter, Berlin, pp. 1–402.
- Blanke, A. & Wesener, T. (2014) Revival of forgotten characters and modern imaging techniques help to produce a robust phylogeny of the Diplopoda (Arthropoda, Myriapoda). *Arthropod Structure and Development*, 43, 63–75.
<http://dx.doi.org/10.1016/j.asd.2013.10.003>
- Clark, V.C., Raxworthy, C.J., Rakotomalala, V., Sierwald, P. & Fisher, B.L. (2005) Convergent evolution of chemical defense in poison frogs and arthropod prey between Madagascar and the Neotropics. *Proceedings of the National Academy of Sciences of the United States of America*, 102 (33), 11617–11622.

<http://dx.doi.org/10.1073/pnas.0503502102>

- Enghoff, H. (2003) Diplopoda, Millipedes. In: Goodman, S.G. & Benstead, J.P. (Eds.), *The Natural History of Madagascar*. The University of Chicago Press, pp. 617–627.
- Golovatch, S.I. & Korsos, Z. (1992) Diplopoda collected by the Soviet Zoological Expedition to the Seychelles Islands in 1984. *Acta Zoologica Hungarica*, 38 (1–2), 1–31.
- Hoffman, R.L. (1980) *Classification of the Diplopoda*. Geneva, 237 pp.
- Kime, R.D. & Enghoff, H. (2011) *Atlas of European Millipedes (Class Diplopoda)*. Vol. 1. Pensoft, Sofia-Moscow, 282 pp.
- Mauriès, J.-P. (1980) Diplopes Chilogathes de la Guadeloupe et ses dépendances. *Bulletin du Muséum national d'histoire naturelle*, 4e Série, Section A, 2, 1059–1111.
- Mauriès, J.-P. (1994) Découverte de Diplopes Craspedosomides à Madagascar: *Betscheuma* n. g. de la famille gondwanienne des Pygmaeosomatidae Carl, 1941 (Myriapoda, Diplopoda). *Bulletin du Muséum national d'histoire naturelle*, 4e série, Section A, Zoologie, 16, 55–86.
- Mauriès, J.-P. (1997) Matériel collecté par H. Franz, 1969 à Madagascar: nouvelles données taxonomiques et chorologiques sur le genre *Betscheuma* Mauriès, 1994 (Diplopoda: Craspedosomatida). *Annalen des Naturhistorischen Museums in Wien*, Serie B, 99, 539–554.
- Meinwald, J., Smolanoff, J., McPhall, A.T. & Miller, R.W. (1975) Nitropolyzonamine: A spirocyclic compound from the defensiv glands of a millipede (*Polyzonium rosalbum*). *Tetrahedron Letters*, 28, 2367–2370.
- Pocock, R.I. (1894) Chilopoda, Symphyla and Diplopoda from the Malay Archipelago. In: Weber (Ed.), *Zoologische Ergebnisse der Reise nach Niederländisch Ost-Indien*, 3, pp. 307–404, pls. 19–22.
- Röper, H. (1978) Ergebnisse chemisch-analytischer Untersuchungen der Wehrsekrete von Spirostreptiden, Spiroboliden und Juliden (Diplopoda), von *Peripatopsis* (Onychophora) und von *Polyzonium* (Diplopoda, Colobognatha). *Abhandlungen und Verhandlungen des Naturwissenschaftlichen Vereins in Hamburg*, 21–22, 353–363.
- Saporito, R.A., Donnelly, M.A., Hoffman, R.L., Garraffo, H.M. & Daly, J.W. (2003). A siphonotid millipede (*Rhinotus*) as the source of spiropyrrrolizidine oximes of dendrobatid frogs. *Journal of Chemical Ecology*, 29 (12), 2781–2786.
<http://dx.doi.org/10.1023/b:joec.0000008065.28364.a0>
- Saussure, H. de & Zehntner, L. (1902) Myriapodes de Madagascar, In: Grandidier (Ed.), *Histoire Physique, Naturelle et Politique de Madagascar*, 27 (53), pp. i-viii + 1–356, pls. 13–15.
- Shelley, R.M. & Golovatch, S.I. (2011) Atlas of myriapod biogeography. I. Indigenous ordinal and supra-ordinal distributions in the Diplopoda: Perspectives on taxon origins and ages, and a hypothesis on the origin and early evolution of the class. *Insecta Mundi*, 158, 1–134.
- Shelley, R.M. (1998) Interception of the millipede *Rhinotus purpureus* (Pocock) at quarantine, and potential introduction of the order and family into the Hawaiian Islands (Polyzoniida: Siphonotidae). *Bishop Museum Occasional Papers*, 56, 54–55.
- Verhoeff, K.W. (1937) Über südafrikanische Colobognathen. Vorläufige Mitteilung. *Zoologischer Anzeiger*, 117 (3–4), 85–91.
- Wesener, T., Enghoff, H. & Sierwald, P. (2009). Review of the Spirobolida on Madagascar, with descriptions of twelve new genera, including three genera of 'Fire Millipedes' (Diplopoda). *ZooKeys*, 19, 1–128.
<http://dx.doi.org/10.3897/zookeys.19.221>
- Wesener, T., Bespalova, I. & Sierwald, P. (2010) Madagascar's living giants: discovery of five new species of endemic giant pill-millipedes from Madagascar (Diplopoda: Sphaerotheriida: Arthrosphaeridae: *Zoosphaerium*). *African Invertebrates*, 51 (1), 133–161.
<http://dx.doi.org/10.5733/afin.051.0102>
- Wesener, T., Raupach, M.J. & Decker, P. (2011) Mountain Refugia Play A Role In Soil Arthropod Speciation On Madagascar. A Case Study Of The Endemic Giant Fire-Millipede Genus *Aphistogoniulus* (Diplopoda, Spirobolida, Pachybolidae). *PLoS ONE*, 6 (12), 1–15.
<http://dx.doi.org/10.1371/journal.pone.0028035>
- Wesener, T. (2009) Unexplored richness: discovery of 31 new species of Giant Pill-Millipedes endemic to Madagascar, with a special emphasis on microendemism (Diplopoda, Sphaerotheriida). *Zootaxa*, 2097, 1–134.
- Wood, W.F., Hanke, F.J., Kubo, I., Carroll, J.A. & Crews, P. (2000) Buzonamine, a new alkaloid from the defensive secretion of the millipede, *Buzonium crassipes*. *Biochemical Systematics and Ecology*, 28 (4), 305–312.
[http://dx.doi.org/10.1016/s0305-1978\(99\)00068-x](http://dx.doi.org/10.1016/s0305-1978(99)00068-x)