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Wild bees (*Anthophila*) of Macaronesia: Aspects of biogeography, species diversity, evolutionary patterns and taxonomic problems

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Over the last few years, we have studied aspects of biogeography, taxonomy and the flower-ecological behaviour of *Micrandrena* and *Suandrena* species, especially in the Madeira Archipelago and the western Canary Islands, but also in the Mediterranean zone (Kratochwil & Scheuchl 2013, Kratochwil 2014, Kratochwil et al. 2014, Kratochwil 2015, Kratochwil 2018, Kratochwil & Schwabe in print, in prep.). We also set up a database of the wild-bee species in the Madeira Archipelago in collaboration with Antonio M.F. Aguiar (Laboratório Agrícola, Camacha, Madeira) and Jan Smit (Nationaal Natuurhistorisch Museum, Leiden, The Netherlands); see Kratochwil et al. (2008).

In the frame of these studies, we asked, e.g. about the differences among the Macaronesian archipelagos concerning bee diversity, endemic taxa, areageographical origins and human introductions. With regard to the Madeira Archipelago and the Canary Islands, we analysed possible colonisation processes and species diversifications by *Micrandrena* and *Suandrena* species.

Primarily considered as a distinct biogeographical unit, Macaronesia is today recognised as a region with different biogeographical zones (Azores, Madeira Archipelago, Selvagens, Canary Islands, Cape Verde). We use the historical term 'Macaronesia' to summarise the archipelagos in question.

In the following, we will present the actual status of bee-species diversity of the Macaronesian archipelagos, partly using unpublished data sources of our own in addition to different checklists from literature, publications and analysed material from museums. We correlate the wild-bee diversity and the number of endemic, native and introduced species with the age of the archipelagos, their distance to mainlands, their climatic conditions and habitat diversity.

We are going to prepare species upgrades for species of the *Andrena wollastoni* complex, described by Warncke for some of the Canary Islands; additionally, we will also prepare descriptions of four new subspecies for this complex.

Marginal archipelago, northern zone: The Azores show large distances to mainland sources, and former stepping-stone islands were not present. Additionally, dominant west winds and the oceanicity, combined with relatively low temperatures and the dominance of woody vegetation before human impact did not favour colonisation by wild bees and their

long-time establishment. Therefore, the bee diversity of native species in the Azores is extremely low. The species ($n = 17$, from that 1 endemic) are biogeographical elements of the temperate, West-Palaeartic zone; most of them had been introduced ($n = 15$).

Marginal archipelago, southern zone: The islands of the Cape Verde Archipelago ($n = 14$, from that 9 endemic, 9 native species, only 1 introduced) are young, and the mainland sources are not suitable because of the wet tropical character. There were probably partial colonisation processes from the Canary Islands. Former stepping-stone islands were not present.

Central archipelagos: The Madeira Archipelago (19 species with 8 endemic species and 1 endemic subspecies) and especially the Canary Islands (124 species with 64 endemic species and 149 taxa with 88 endemic taxa) show environmental conditions that favoured the existence and evolutionary processes of wild-bee species. The relatively high age of some islands, the high habitat diversity, geological barriers that led to separation of populations, sources from the Saharo-Mediterranean high-diversity bee spot in the case of the Canary Islands, probably former stepping-stones islands in the case of the Madeira Archipelago and the tradewind exposure supported colonisations and after that evolution of endemic bee species. With regard to the subgenus *Micrandrena*, there are indications that probably *A. tiaretta* or an ancestor colonised the Madeira Archipelago and the Canary Islands. On Porto Santo Island, this species evolved into the endemic *A. dourada*. Our hypothesis is that *A. dourada* colonised from Porto Santo the much younger Madeira Island and evolved to *A. wollastoni*. Similar processes can be reconstructed for the western Canary Islands.

The Canary Islands are a hot spot for bee diversity with many different taxonomical units. This is unique world-wide for an oceanic archipelago. Although Fuerteventura, Lanzarote and Gran Canaria are the oldest islands with the highest bee species diversity ($n = 67$, $n = 62$, $n = 66$), Tenerife also has remarkable bee diversity ($n = 63$) with many endemic species ($n = 38$). The biogeographical situation with former palaeo islands favoured the development of endemic taxa in Tenerife. The small Selvagens Islands only have one bee species. This archipelago, the eldest of Macaronesia, is an example of an ancient and today highly eroded island complex.

Introduced species: In the extreme environments of the Canary Islands and especially Porto Santo (Madeira Archipelago) and Cape Verde, nearly no introduced bee species exist in contrast to the Azores, which probably has 15 or perhaps 16 introduced species (out of 17).

Plant-bee interactions, nature conservation: Many of the endemic plant species of Macaronesia depend on pollination by wild bees, especially the woody *Echium* species. We sampled a lot of data from the Madeira Archipelago and the western Canary Islands, which show many interactions of bee females with endemic plant species, in addition to the data of Hohmann et al. (1993) from the Canary Islands (for Porto Santo: Kratochwil & Schwabe, in prep.).

In actuality, there is still a rich bee life in many areas, despite the high anthropogenic impact (especially critical are banana plantations and their surroundings, golf courses and construction areas, which strongly reduce or even eliminate bee populations). National parks

and other protected areas as well as difficult relief situations with no possibility for construction projects and without intensively agricultural use help to protect the rich bee fauna, which is characteristic especially of the Canary Islands. The two endemic bee species (*Andrena dourada* and *A. portosanctana*) of the anthropogenically highly influenced island of Porto Santo (Madeira Archipelago) are threatened, and their survival is not guaranteed.

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