



BOCAGIANA

Museu de História Natural do Funchal

The drosophilids (Diptera: Drosophilidae) from a *Laurisilva* patch in Madeira with two new records for this island

With 2 figures and 2 tables

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ABSTRACT: The drosophilid fauna of Madeira consists of 20 species from 6 different genera, including one endemic species, *Drosophila madeirensis* Monclús, 1984. In spite of several studies on Madeira drosophilids, little is known on the spatial distribution and phenology of most species, particularly of those associated to the native laurel forest. In this study, the drosophilid fauna of a *Laurisilva* patch was studied over an 18-month period in Chão da Ribeira (Seixal, northern Madeira) using several sampling techniques. As a result of this study, seventeen species were recorded including two new records for Madeira: *Drosophila phalerata* (Meigen, 1830) and *Lordiphosa* n. sp., a new unnamed species. The current knowledge of Madeiran drosophilid fauna is also briefly discussed.

Keywords: Drosophilidae, Madeira Island, *Laurisilva*, species inventories, new records.

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Bocagiana (2014) 238: 1-8

ISSN 2183-3141 (online edition)

Available online at: <http://bocagiana.cm-funchal.pt>

Edição do Departamento de Ciência da Câmara Municipal do Funchal. MANUEL BISCOITO (Editor)

Received 27 February 2014; Revised 05 March 2014; Accepted 06 March 2014; Published 19 September 2014

RESUMO: A fauna de drosofilídeos da Madeira inclui 20 espécies pertencentes a 6 géneros, incluindo uma espécie endémica, *Drosophila madeirensis* Monclús, 1984. Apesar de existirem diversos estudos sobre a fauna desta família de dípteros da ilha da Madeira, existe pouca informação sobre a distribuição espacial e a fenologia da maioria das espécies, em particular sobre as que estão associadas à floresta nativa: a Laurissilva. Os drosofilídeos de uma área de Laurissilva foram estudados utilizando várias técnicas de amostragem. No total foram colhidas 17 espécies de drosofilídeos, incluindo duas novas espécies para a ilha: *Drosophila phalerata* (Meigen, 1830) e *Lordiphosa* n. sp.. O estado atual do conhecimento da fauna de drosofilídeos da Madeira é ainda brevemente discutido.

Palavras-chave: Drosophilidae, ilha da Madeira, *Laurissilva*, inventários de espécies, novos registos.

INTRODUCTION

Madeira Island is a biodiversity hotspot with a considerable number of endemic plant and animal species (BORGES *et al.*, 2008). The Madeira archipelago, together with other Macaronesian islands, is part of the Mediterranean hotspot, one of the 34 Global Biodiversity Hotspots (MYERS *et al.*, 2000). Furthermore, due to its unique biodiversity and conservation status, the laurel forest (*Laurissilva*) of Madeira was recognized by UNESCO as a World Heritage Site (IUCN, 1999). In the last few years, a comprehensive species checklist of the terrestrial flora and fauna of Madeira archipelago has been published (BORGES *et al.*, 2008), followed by the identification of conservation priorities among native plants and animals (MARTÍN *et al.*, 2008) together with the list of the most threatening invasive species to Madeira biodiversity (SILVA *et al.*, 2008). However, the knowledge on arthropod diversity of Madeira is far from being complete, as can be attested by recent discoveries of new species, even for well-studied taxonomic groups like ground beetles (DONABAUER, 2008; WRASE, 2010).

The drosophilid fauna of Madeira was previously studied by BECKER (1908), FREY (1939, 1949) and MONCLÚS (1984). Remarkably, until 1984, only 9 species were known to occur in this archipelago, but since then this number more than doubled. In recent years several checklists of Madeiran drosophilids were published (BÄCHLI & BÁEZ, 2002; ROCHA PITÉ, 2002; BÄCHLI, 2008), but they are not consensual concerning the taxonomic entities that occur in Madeira (see results and discussion). In addition to the species mentioned in these checklists, some publications refer genetic data of *Zaprionus indianus* Gupta, 1970 collected in Madeira (e.g. NARDON *et al.*, 2005; YASSIN *et al.*, 2008); a species never recorded in faunistic studies published for this archipelago.

In spite of the reasonable number of studies on Madeira drosophilids, most of them represent *ad-hoc* sampling along various locations (e.g. BECKER, 1908; FREY, 1939, 1949; MONCLÚS, 1984) or are focused on genetic and physiological issues using particular species as model organisms (e.g. KHADEM *et al.*, 2001, 2012; LEPETIT *et al.* 2002; NARDON *et al.*, 2005; REGO *et al.*, 2006, 2007a, 2007b; REGO & BOIEIRO, 2010). Consequently, basic ecological information, such as species distribution, abundance, phenology or habitat associations, is lacking for most of Madeiran drosophilid species.

Here we present the results from a survey on the drosophilid species present in a *Laurissilva* patch using nine different sampling techniques and encompassing more than an annual cycle. Furthermore, the present knowledge on the taxonomy of Madeira drosophilid fauna is briefly discussed.

MATERIAL AND METHODS

This study was carried out from February 1997 to July 1998 in the northern part of Madeira Island at Chão da Ribeira (32, 80° N - 17, 11° E) (Fig. 1). Six sampling sites were selected in a *Laurissilva* patch: three were located in a well preserved area and another three in an area subjected to human disturbance (e.g. agricultural and forestry activities). The three sites located in the well preserved area were dominated by native tree species, namely *Clethra arborea*, *Laurus novocanariensis*, *Ocotea foetens* and *Persea indica*, while the other three sites located in a disturbed area had some introduced plant species, like *Ageratina adenophora*, *Castanea sativa*, *Eucalyptus globulus*, *Juglans regia* and *Pinus pinaster*. A detailed description of the study area is presented elsewhere (CAPELA *et al.*, 2000).

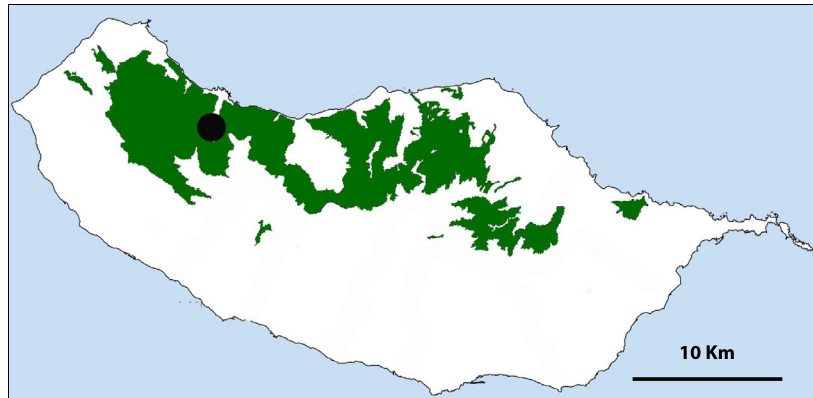


Fig. 1 – Location of the study area at Chão da Ribeira (black circle) and the distribution of *Laurisilva* in Madeira Island (in green).

In this study we aim to provide the drosophilid species inventory from Chão da Ribeira. For this reason, sampling effort was considerable and involved the combined use of a variety of sampling techniques, namely baited traps with fermented fruits, Moericke traps, light traps (both pirbright traps and CDC traps), pitfall traps, Malaise traps and vegetation sweeping with entomological nets. Sampling was performed on a monthly basis over an 18-month period. Details of the sampling methodology and techniques used will be discussed elsewhere (REGO *et al.*, *in prep.*). The specimens collected in this study were deposited in the entomological collection of the Faculty of Sciences, University of Lisbon (Lisbon, Portugal).

RESULTS AND DISCUSSION

Overall, 13,847 drosophilid specimens from 17 species belonging to four genera were collected in this study (Table 1). Of these, 11 belong to the genus *Drosophila*, three to *Scaptomyza*, two to *Lordiphosa*, while *Hirtodrosophila* is represented by a single species. Two species, *Drosophila phalerata* Meigen, 1830 and *Lordiphosa* n. sp, are new records for Madeira Island, the last one being a new species to science under formal description (REGO *et al.*, *in prep.*).

Table 1 – Number of specimens of each drosophilid species collected by the several sampling methods. BT – baited traps with fermented fruit; PIT – pitfall traps; MO – Moericke; MA – Malaise; CDC – CDC light trap; PIR – pirbright light trap; ARB – sweeping the arboreal layer; HERB – sweeping the herbaceous layer.

	BT	PIT	MO	MA	CDC	PIR	ARB	HERB	Total
<i>Drosophila busckii</i> Coquilett, 1901	0	1	1	0	0	9	45	0	56
<i>Drosophila funebris</i> (Fabricius, 1787)	27	0	0	2	0	1	175	0	205
<i>Drosophila immigrans</i> Sturtevant, 1921	9119	15	6	15	15	4	1	15	9190
<i>Drosophila phalerata</i> Meigen, 1830	101	0	0	0	4	1	0	0	106
<i>Drosophila hydei</i> Sturtevant, 1921	43	0	0	6	0	0	0	0	49
<i>Drosophila mercatorum</i> Patterson & Wheeler, 1942	0	0	0	0	0	0	1	0	1
<i>Drosophila repleta</i> Wollaston, 1858	1	1	0	0	0	0	0	0	2
<i>Drosophila melanogaster</i> Meigen, 1830	174	0	7	0	0	0	0	0	181
<i>Drosophila simulans</i> Sturtevant, 1919	2409	6	14	1	155	28	3	3	2659
<i>Drosophila madeirensis</i> Monclús, 1984	675	3	0	0	2	0	0	0	680
<i>Drosophila subobscura</i> Collin, 1936	311	6	0	0	0	1	0	0	318
<i>Hirtodrosophila cameraria</i> (Haliday, 1833)	65	1	5	0	4	1	12	31	119
<i>Lordiphosa andalusiaca</i> (Strobl, 1906)	0	0	4	4	0	0	5	0	13
<i>Lordiphosa</i> n. sp.	0	0	20	0	0	0	0	0	20
<i>Scaptomyza pallida</i> (Zetterstedt, 1847)	0	1	31	156	0	63	2	0	253
<i>Scaptomyza flava</i> (Fallén, 1823)	0	0	1	0	0	0	0	0	1
<i>Scaptomyza graminum</i> (Fallén, 1823)	0	0	4	2	0	2	1	0	9
TOTAL	12925	34	93	186	180	151	245	49	13862

This is the first comprehensive study on the drosophilid fauna of Madeira *Laurisilva*, encompassing the annual cycle with both intensive and extensive (in time) field sampling. Taking in consideration the sampling effort and its spatial distribution, we consider that the inventory of the Drosophilidae at Chão da Ribeira is near complete.

The most recent compilation of Madeiran drosophilids (BÄCHLI, 2008) reports twenty-six species, a number higher than in the previous taxonomic checklists for this island (BÄCHLI & BÁEZ, 2002 – 20 species; ROCHA PITÉ, 2002 – 21 species), however seven of the recorded species in this work are synonymies of other species also included in the list. Thus, *Drosophila ampelophila* Loew, 1862 and *Drosophila fasciata* Meigen, 1830 are synonymies of *Drosophila melanogaster* Meigen, 1830; *Drosophila forcipata* Collin, 1952 is a synonymy of *Lordiphosa andalusiaca* (Strobl, 1906); *Scaptomyza apicalis* (Hardy, 1849) and *Drosophila flaveola* Meigen, 1830 are synonymies of *Scaptomyza flava* (Fallén, 1823); *Scaptomyza tetrasticha* Becker, 1908 is a synonymy of *Scaptomyza graminum* (Fallén, 1823) and finally *Scaptomyza disticha* (Duda, 1921) is a synonymy of *Scaptomyza pallida* (Zetterstedt, 1847). In addition, BÄCHLI (2008) omitted from his checklist *Lordiphosa fenestrarum* (Fallén, 1823), a species recorded by FREY (1949) from Funchal and Rabaçal. Moreover *Zaprionus indianus*, a species not formally reported from Madeira, was cited from this island (without a precise localization) in genetic studies aiming to trace this species recent expansion and colonization of new areas (e.g. NARDON *et al.*, 2005; YASSIN *et al.*, 2008). ROCHA PITÉ (2002) included on her checklist *Drosophila obscura* previously recorded by BECKER (1908) and FREY (1949). However, other authors consider that records of *D. obscura* are possible misidentifications of *Drosophila subobscura* (Monclús, 1984; BÄCHLI & BÁEZ, 2002). Putting together all this information, we consider that the number of drosophilid species known to occur in Madeira is 20 (Table 2).

Table 2 – Species records of drosophilids reported to Madeira Island based on published literature. New records from this work are indicated in bold.

GENUS	SPECIES
<i>Drosophila</i>	<i>Drosophila busckii</i> Coquillett, 1901
	<i>Drosophila funebris</i> (Fabricius, 1787)
	<i>Drosophila immigrans</i> Sturtevant, 1921
	<i>Drosophila phalerata</i> Meigen, 1830
	<i>Drosophila buzzatii</i> Patterson & Wheeler, 1942
	<i>Drosophila hydei</i> Sturtevant, 1921
	<i>Drosophila mercatorum</i> Patterson & Wheeler, 1942
	<i>Drosophila repleta</i> Wollaston, 1858
	<i>Drosophila virilis</i> Sturtevant, 1916
	<i>Drosophila ananassae</i> Doleschall, 1858
	<i>Drosophila melanogaster</i> Meigen, 1830
	<i>Drosophila simulans</i> Sturtevant, 1919
	<i>Drosophila madeirensis</i> Monclús, 1984
<i>Drosophila subobscura</i> Collin, 1936	
<i>Hirtodrosophila</i>	<i>Hirtodrosophila cameraria</i> (Haliday, 1833)
<i>Lordiphosa</i>	<i>Lordiphosa andalusiaca</i> (Strobl, 1906)
	<i>Lordiphosa n. sp.</i>
<i>Scaptodrosophila</i>	<i>Scaptodrosophila lebanonensis</i> (Wheeler, 1949)
<i>Scaptomyza</i>	<i>Scaptomyza pallida</i> (Zetterstedt, 1847)
	<i>Scaptomyza flava</i> (Fallén, 1823)
	<i>Scaptomyza graminum</i> (Fallén, 1823)
<i>Zaprionus</i>	<i>Zaprionus indianus</i> Gupta, 1970

The work here presented added two new records for Madeira Island, *D. phalerata* and *Lordiphosa n. sp.*, increasing the number of drosophilid species to 22 (Table 2). The number of species recorded at Chão da Ribeira (17) is remarkable, considering that they represent 75% of the species previously known to occur in Madeira. The high number of species found at Chão da Ribeira probably reflects the variety of ecological conditions at this location, which vary from pristine native forest to disturbed forest with some introduced plants. Furthermore, sampling encompassed more than a full

year and the variety of sampling techniques applied targeted different microhabitats. This may explain the presence of cosmopolitan and widespread species, like *Drosophila melanogaster*, *D. immigrans*, *D. subobscura*, *D. phalerata*, *Hirtodrosophila cameraria* and *Lordiphosa andalusiaca*, but also the occurrence of endemic species with a more restricted distribution like *D. madeirensis* and the new *Lordiphosa* species.

Drosophila immigrans Sturtevant, 1921 was the most abundant species in our survey, both in preserved and disturbed *Laurisilva*, accounting for 66% of all captures (Table 1). This large number of specimens of *D. immigrans* in a natural area is an interesting fact given that it is considered a cosmopolitan domestic species, although it can also occur in natural habitats (e.g. BÄCHLI & BLASCO-ZUMETA, 1995; ROCHA PITÉ *et al.*, 1999; BÄCHLI *et al.*, 2004). It is believed that this species had its origin in the Pacific but, in the early 20th century, colonized North America and probably also Europe (STURTEVANT, 1921). *D. immigrans* was never found in such high abundance in previous studies performed on Madeira *Laurisilva* (e.g. MONCLÚS, 1984; A. BREHM, *pers. com.*). Furthermore, this species changed dramatically in abundance in Chão da Ribeira becoming the most abundant drosophilid while the endemic *D. madeirensis* decreased in abundance when compared with previous collections in the same area (A. BREHM, *pers. com.*). This may indicate that this patch of *Laurisilva* may be suffering some habitat deterioration, but further studies are needed to confirm this assumption.

Drosophila madeirensis Mónclus, 1984 was the only known endemic drosophilid from Madeira and is believed to be associated with *Laurisilva* (MONCLÚS, 1984). This species is known to occur in eight localities: Chão da Ribeira, Chão dos Louros, Curral das Freiras, Fajã da Nogueira, Queimadas, Rabaçal, Ribeiro Frio and Terreiro da Luta (e.g. MONCLÚS, 1984; ACOSTA *et al.*, 1995; LEPETIT *et al.*, 2002; REGO *et al.*, 2006), but its distribution and ecology are still poorly known. In the present survey, the endemic *D. madeirensis* is the third most abundant species, however it accounts for only 5% of all captured individuals (see Table 1).

Other drosophilid species, like *D. mercatorum*, *D. repleta*, *L. andalusiaca*, *S. flava* and *S. graminum*, were particularly uncommon at Chão da Ribeira (see Table 1). The detection of several species, including the new endemic *Lordiphosa*, was only possible due to the use of complementary sampling techniques, some of which proved to be effective, in spite of not being traditionally used to sample drosophilids, such as pitfall, Moericke and Malaise traps.



Fig. 2 – A female specimen of *Drosophila phalerata* (in lateral view). Photo by Darren J. Obbard used with permission.

The new *Lordiphosa* species was recorded in higher abundance from December 1997 to January 1998 and was collected using Moericke traps, a less common method to sample drosophilids. Curiously, it was collected in an area of disturbed *Laurisilva* containing a mixture of both native and introduced plants (REGO *et al.*, *in prep.*). The fact that it was not collected with baited traps (Table 1) might indicate that this species probably does not use fermented fruit and decaying vegetable matter as a food or oviposition resource. Moericke traps use colour (yellow in this case) as an attractant which might suggest that this species could use flowers as a resource. *Drosophila phalerata* Meigen, 1830 is a widespread Palearctic species (BÄCHLI *et al.*, 2004) (Fig. 2). The species is also known from the neighbouring archipelago of the Azores, where it was only reported from São Miguel Island (SÉGUY, 1936; FREY, 1945). It uses fungi as breeding substratum (BÄCHLI *et al.*, 2004) and thus is usually more abundant in Autumn.

The fact that three new drosophilid species were recently recorded for Madeira – *Zaprionus indianus* (NARDON *et al.*, 2005; YASSIN *et al.*, 2008), *Drosophila phalerata* and *Lordiphosa* n. sp. (present study) – highlights the poor knowledge on the drosophilid fauna of this island and the need for further studies on this subject. Moreover, Madeira has an outstanding biodiversity, particularly in what concerns invertebrate life forms, and efforts should be addressed to study, protect and value this unique Natural Heritage.

ACKNOWLEDGEMENTS

The authors wish to thank M. T. Rocha Pité for her help in drosophilid identification, we are also grateful to Isamberto Silva, Fernando Nunes, Maurílio Freitas, Letícia Romão and Sérgio Teixeira for their help during fieldwork and specimen sorting, and Darren J. Obbard for permission to use the photo of *Drosophila phalerata*. This work was financed by Fundação para a Ciência e a Tecnologia (FCT) through projects PRAXIS/2/2.1/BIA/283/94 and PTDC/BIA-BEC/99138/2008. CR and MR were supported by FCT grants SFRH/BPD/91357/2012 and SFRH/BPD/86215/2012 respectively.

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