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An overview of the spider fauna of Maio (Cape Verde Islands), with some additional recent records (Arachnida, Araneae)

Rainer Breitling [1], Amelia Coleing [2], Tiago Peixoto [2], Helen Nagle [2], E. Geoffrey Hancock [3], Robert N. Kelsh [4] & Tamás Székely [4]

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ABSTRACT

Based on a collection of spiders obtained during ecological fieldwork in 2009 and an extensive literature review, we summarize the current state of knowledge of spider biodiversity on the island of Maio. The total number of species reported from Maio is now 46, representing 18 families and including 16 species (35%) endemic to the Cape Verde Islands. The family Dictynidae (meshweb spiders), represented by the saline-adapted ***Devade*** cf. ***indistincta***, is reported for the first time from Cape Verde.

RESUMO

No seguimento de estudos ecológicos e trabalho de campo correspondente realizados em 2009, e após extensa revisão bibliográfica, sumarizamos o actual conhecimento acerca da biodiversidade das aranhas na ilha de Maio. O número total de espécies identificadas aumentou para 46, sendo estas representantes de 18 famílias, nas quais se incluem 16 espécies (35%) endémicas de Cabo Verde. É pela primeira vez descrita em Cabo Verde a família Dictynidae, representada pela ***Devade*** cf. ***indistincta***, adaptada à salinidade.

[1] Institute of Molecular, Cell and Systems Biology, College of Medical, Veterinary and Life Sciences, University of Glasgow, Glasgow G12 8QQ, UK; e-mail rainer.breitling@glasgow.ac.uk
[2] Centre for Ecology and Conservation, University of Exeter, Penryn TR10 9EZ, UK
[3] Hunterian Museum (Zoology), Graham Kerr Building, University of Glasgow, Glasgow G12 8QQ, UK
[4] Biodiversity Lab, Dept. of Biology & Biochemistry, University of Bath, Bath BA2 7AY, UK

INTRODUCTION

Spiders are common predators in almost all terrestrial ecosystems, and they are widely used as ecological indicators (Clausen 1986, Gibson ***et al.*** 1992, Wise 1993, Duffey & Feest 2009). Compared to that of other Macaronesian archipelagos, the spider fauna of the Cape Verde Islands is only poorly known. For example, in their recent study of spider diversity and evolution in Macaronesia, Cardoso ***et al.*** (2010) had to exclude Cape Verde from their analysis due to insufficient knowledge, despite a long history of arachnological reports from Cape Verde.

The history of Cape Verde spider studies started with John Blackwall's 1865 description of material collected by John Gray, containing 19 species mostly from the islands of Santo Antão, Santiago and São Nicolau (Blackwall 1865). This was followed by a series of publications summarizing the results of various expeditions (e.g. Simon 1883, 1897, Berland 1936, Berland & Denis 1946, Denis 1941, 1944). These works, together with findings on about 280 specimens collected in 1978–1980, were summarized in the first detailed preliminary checklist of spiders from Cape Verde by Assmuth & Groh (1982), who report a total of 67 species, including five species from Maio.

Since then, the interest in spiders from Cape Verde has been surprisingly limited. In addition to a number of papers treating individual families (e.g. jumping spiders, Salticidae; Wesołowska 1989, 1998) or single species (***Koinothrix pequenops***; Jocqué 1981), the only recent comprehensive treatments of Cape Verdean spiders are those by Günther Schmidt and his collaborators (Schmidt 1996, 1997a, b, c, d, 1999, 2001, Schmidt & Bauer 1994, Schmidt ***et al.*** 1994, Schmidt & Krause 1994, 1995, 1998). During a large number of field trips covering all inhabited islands of Cape Verde, Schmidt almost doubled the number of species known for the archipelago, including numerous newly described species. Despite the limitations of Schmidt's work (Wunderlich 1987), in particular the lack of informative illustrations, his publications still represent the most valuable summary of the status of Cape Verdean arachnology. In addition, the single Portuguese language publication on the spider fauna of Cape Verde is a brief report by Baessa-de-Aguiar (1998) on new records for 19 species from various islands.

The present study focuses on a small collection of spiders from the island of Maio, at 269 km^2 one of the smaller of the Cape Verde islands. Maio is largely a dry semi-desert island dissected by numerous ravines with seasonal water flow. Some of the characteristic habitats are rocky and sandy shores, salt pans (Salinas de Porto Inglês), sand dunes, salt marshes and arid mountainous grassland.

The Cape Verde government has recognized eight protected areas on Maio, including Terras Salgadas National Park, Natural Park of Ribeira de Lagoa and Salinas de Porto Inglês Landscape Reserve (Natura 2000). The objective of the current study was to collect data on the biodiversity of various plant and animal taxa. Here we present details of the arachnid specimens obtained during these surveys.

MATERIAL AND METHODS

Fieldwork was carried out from 15 April 2009 to 30 May 2009 and from 10 September 2009 to 8 October 2009 at two sites: Salinas de Porto Inglês (15° 9' N, 23° 13' W) and Ribeira de Lagoa (15° 8' N, 23° 9' W). At both sites pitfall traps were dug along 50 m and 25 m transects in April and September, respectively. Small, plastic cups (70 mm diameter, 200 ml volume) were buried, with the top of the cup level with the soil. One cup was positioned every 5 m along the transect and then left for 24 hours. In April, twelve 50 m transects were put in place at Salinas de Porto Inglês and nine 50 m transects at Ribeira de Lagoa. In September, thirteen 25 m transects were put in place at Salinas de Porto Inglês and six 25 m transects at Ribeira de Lagoa. The total sampling effort was 132 trap-days at Salinas de Porto Inglês and 99 trap-days at Ribeira de Lagoa in April and 78 trap-days at Salinas de Porto Inglês and 36 trap-days at Ribeira de Lagoa in September. At

Salinas de Porto Inglês, transects were placed in sand dunes and arid land under ***Acacia*** trees (***Acacia americana***, ***A. tortilis***), whereas at Ribeira de Lagoa the transects were placed in agricultural land, dry riverbed and arid land with ***Acacia*** trees. Different locations in the same habitat and vegetation types were sampled in April and September. A few spiders were also collected fortuitously by hand. All specimens were preserved in 92% alcohol in sealed plastic vials; in most cases the vials were labeled with the GPS coordinate of the specimen, the site name and the date. Specimens were deposited in the collection of the Zoology Museum of the University of Glasgow (GLAHM). Nomenclature follows Platnick (2011).

RESULTS

Our invertebrate collection from Maio, Cape Verde Islands, contains a total of 16 spider species from 11 families (73 specimens, representing about 14% of the known Cape Verde spider fauna; cf. Schmidt ***et al.*** 1994). Spiders were the third most abundant invertebrate order in the pitfall trap samples, appearing in almost equal numbers to beetles (Coleoptera) and ants (Hymenoptera). The abundance of spiders was clearly not biased by the presence of one or two hyper-abundant species: the most abundant spider, the endemic ground-spider ***Berlandina nigromaculata***, constitutes only 16% of the material.

Schmidt ***et al.*** (1994) reported 20 spider species from Maio, which was increased to 36 species by Schmidt & Krause (1998) and Schmidt (1999). Our collection contains six of these and adds 10 new species (marked * below) to the known spider fauna of Maio. Five of the species in our sample are endemic to the Cape Verde Islands (marked ^{E}).

Araneidae – Orb-web spiders

Neoscona cf. ***subfusca**** (C. L. Koch, 1837)
Maio: no location details, 1F, IX.2009, GLAHM 140439.
A single, badly damaged female specimen is tentatively assigned to ***Neoscona subfusca***, the most widely distributed (and highly variable) species of the genus (Grasshoff 1986).
gen. sp. 1*
Maio: no location details, 1M, IX.2009, GLAHM 140438.
One male araneid specimens collected in September 2009 has not yet been identified to species, but is certainly new for Maio and probably new to the Cape Verde Islands, as it does not match any of the species reported from the archipelago so far.

Other araneid species reported by Schmidt (1999): ***Argiope sector*** (Forsskål, 1776).

Dictynidae – Meshweb spiders

Devade cf. ***indistincta**** (O. P.-Cambridge, 1872)
Maio: Lagoa, 4M, IX.2009, GLAHM 140402, GLAHM 140404, GLAHM 140426; Maio: no location details, 1M, IX.2009, GLAHM 140440.
The five ***Devade*** cf. ***indistincta*** males are the first record of this species (and this family) from the Cape Verde Islands. The species is widespread in saline and sandy habitats around the Mediterranean (Simon 1911), often close to the coast, from Spain and Algeria in the west to Syria in the east (Esjunin 1994, Esjunin & Efimik 2000). On Maio, these small spiders were mostly collected together with ***Hogna*** cf. ***ferox***, all of them in September at the Lagoa sampling site. The Cape Verde specimens are only tentatively identified as ***D. indistincta***, but may belong to a new related species, as there are slight differences in the male palp compared to the illustrations in Esjunin & Efimik (2000), in particular a less prominent lateral hook of the conductor. Individual males from southern France, Tunisia and Egypt examined in the Muséum national d'Histoire naturelle, Paris (MNHN B.443, AR444, AR449, AR 5286; all identified as "***D. hirsutissima*** (E. Simon)")

showed considerable variation in pedipalpal morphology. A revision of a larger amount of material covering the wide range of the species is desirable before a final decision on the taxonomic status of the Maio material is made.

Gnaphosidae – Ground spiders

Berlandina nigromaculata[E] (Blackwall, 1865)
Maio: Lagoa, 4M, 1F, 1 subadult M, IX.2009, GLAHM 140384, GLAHM 140386, GLAHM 140391; Maio: Salina, 1F, 19.IV.2009, GLAHM 140429; 1 juvenile, 25.IV.2009, GLAHM 140380; 1M, 22.V.2009, GLAHM 140382; 4M, 1F, 1 juvenile, IX.2009, GLAHM 140390, GLAHM 140394, GLAHM 140392.
This endemic species was collected as adults and juveniles in both April and September 2009, at all sampling sites. This relatively large, cream-colored spider is one of the most abundant species on the island of Maio.

Zelotes laetus (O. P.-Cambridge, 1872)
Maio: Salina, 3M, 2F, IX.2009, GLAHM 140406, GLAHM 140407, GLAHM 140419, GLAHM 140423; Maio: no location details, 1F, IX.2009, GLAHM 140444.
Z. laetus was found only in September 2009 at Salinas de Porto Inglês. For a long time, this species was considered endemic to the Cape Verde Islands (under the name ***Zelotes salensis*** Berland, 1936, after the type locality on the island of Sal). It was only recently synonymized with the cosmopolitan species ***Z. laetus*** (FitzPatrick 2007). However, the wide and disjunct distribution of this species (which includes Africa north of the equator, France, Portugal, Israel, Saudi Arabia, the southwestern United States, Mexico, Peru, Hawaii and the Galapagos Islands) is quite atypical for a gnaphosid spider. Comparable patterns are only found in the originally Mediterranean species ***Zelotes nilicola*** (O. P.-Cambridge, 1874), ***Trachyzelotes jaxartensis*** (Kroneberg, 1875), ***T. kulczynskii*** (Bösenberg, 1902) and ***T. lyonneti*** (Audouin, 1826), and in the synanthropic species ***Scotophaeus blackwalli*** (Thorell, 1871) and ***Urozelotes rusticus*** (L. Koch, 1872). Therefore, the taxonomic status of the Cape Verde specimens (and especially the synonymy with the American populations) deserves additional study.

Other gnaphosid species reported by Schmidt (1999): ***Australoechemus celer***[E] Schmidt & Piepho, 1994, ***Drassodes assimilatus*** (Blackwall, 1865), ***Setaphis atlantica***[E] (Berland, 1936).

Linyphiidae – Dwarf spiders

gen. sp. 2*
Maio: Salina, 1F, IX.2009, GLAHM 140408.
The single linyphiid female from Salinas Porto Inglês clearly does not belong to the only linyphiid species described before from Cape Verde (***Koinothrix pequenops*** Jocqué, 1981). It is a tiny, large-eyed, pale spider, which because of the epigynal structure could belong to the species reported as "***Meioneta*** spec." from São Vicente by Assmuth & Groh (1982). A definitive taxonomic assignment will require additional material, in particular male specimens.

Lycosidae – Wolf spiders

Arctosa variana* C. L. Koch, 1847
Maio: Salina, 1M, 11.V.2009, GLAHM 140410; 1 subadult M, IX.2009, GLAHM 140393; Maio: Lagoa, 1 juvenile, 22.IV.2009, GLAHM 140411.
This species seems to be widespread on the island, but rather rare. Single juveniles were found at both sampling sites. The only adult specimen was collected in May 2009 at the Salina.

Hogna cf. ***ferox*** (Lucas, 1838)
Maio: Lagoa, 1F, 15.IV.2009, GLAHM 140428; 1M, 25.IV.2009, GLAHM 140395; 13M, 1F, IX.2009, GLAHM 140385, GLAHM 140387, GLAHM 140397, GLAHM 140399, GLAHM 140401, GLAHM 140403, GLAHM 140417; Maio: Salina, 1 subadult M, IX.2009, GLAHM 140405; Maio: no location details, 1M, IX.2009, GLAHM 140400.

This is the most abundant species in our sample, almost exclusively collected in September 2009 from the Lagoa site. The predominance of male specimens is noteworthy, indicating a pronounced difference in mobility of the sexes. Wunderlich (1991) considers ***H. ferox*** s. str. to be endemic to the Canary Islands, in which case the correct name for the Cape Verde species would probably be ***H. helva*** (Blackwall, 1865).

Other lycosid species reported by Schmidt (1999): ***Allocosa caboverdensis***[E] Schmidt & Krause, 1995.

Nephilidae – Giant orb-web spiders

Nephila senegalensis (Walckenaer, 1841)
Maio: Lagoa, 1F, 8.V.2009, GLAHM 140409.
One female of this striking black-and-yellow spider was collected by hand from its web high in a tree at Ribeira de Lagoa.

Oxyopidae – Lynx spiders

Oxyopes cf. ***caboverdensis****[E] Schmidt & Krause, 1994
Maio: Lagoa, 1M, IX.2009, GLAHM 140416.
A single specimen was collected in September 2009 at Ribeira de Lagoa.

Other oxyopid species reported by Schmidt (1999): ***Peucetia viridis*** (Blackwall, 1858**).**

Philodromidae – Running crab spiders

Thanatus atlanticus[E] Berland, 1936
Maio: Salina, 1M, IX.2009, GLAHM 140421.
This is the only valid species that has Maio as its type locality, having been described by Berland based on a female specimen collected in July 1934 on Maio by Auguste Chevalier (MNHN B.1567). The male assigned here to ***Thanatus atlanticus*** was initially thought not to match the male tentatively identified as belonging to this species by Schmidt & Krause (1995). The tibial apophysis is long, thin and pointed, different from the figure in Schmidt & Krause (1995). Examination of Schmidt's specimen in the Senckenberg Museum in Frankfurt am Main (SMF38024-128; "Kapverden: Boavista: Lavageröll bei Sal Rei: G. Schmidt leg. u. det. 16.4.1994") shows, however, that the figure is misleading: the Boavista specimen clearly possesses the same strongly sclerotized pointed tibial apophysis as the Maio specimen.

Thanatus vulgaris* Simon, 1870
Maio: Salina, 1M, IX.2009, GLAHM 140422.
Collected in September 2009 at Salinas de Porto Inglês. Several juvenile philodromid specimens collected at Riberia de Lagoa and Salinas de Porto Inglês in September 2009 may also belong to this widespread species.

Salticidae – Jumping spiders

Pellenes cf. ***vanharteni****[E] Wesołowska, 1998
Maio: Lagoa, 1M, 2.V.2009, GLAHM 140412; Maio: Salina, 1M, 10.V.2009, GLAHM 140424; 1M, 22.V.2009, GLAHM 140383; 1M, 1F, IX.2009, GLAHM 140420, GLAHM 140427.
Adult specimens tentatively assigned to this species were mainly collected in May and September 2009 at Salinas de Porto Inglês.

Wesolowskana lymphatica[E] (Wesołowska, 1989)
Maio: Vila [do Maio], 1M, 15.IV.2009, GLAHM 140418; 1F(?), 19.IV.2009, GLAHM 40414.
This species was collected in April 2009 at Vila do Maio. The female specimen is badly damaged and has not been identified with certainty. This species has probably had the most dynamic taxonomic history of all the endemic spiders of Cape Verde. Described only in 1989, as ***Luxuria lymphatica*** (Wesołowska 1989), it has also been reported as ***Baryphas dubius*** (originally used for the male of ***L. lymphatica***, described in the same paper), ***Hyllus dubius***, and ***Blaisea dubia***, illustrating the still fluid state of salticid taxonomy.

Other salticid species reported by Schmidt (1999): ***Menemerus bivittatus*** (Dufour, 1831), ***Phlegra insulana***[E] Schmidt & Krause, 1998, ***Wesolowskana marginella***[E] (Simon, 1883).

Sparassidae – Huntsman spiders

Heteropoda venatoria* (Linnaeus, 1767)
Maio: no location details, 1F, IX.2009, GLAHM 140415.

A single specimen of this large pantropical synanthropic species was collected by hand.

Thomisidae – Crab spiders

Xysticus sp.***
Maio: no location details, 1 subadult F, IX.2009, GLAHM 140443.
The single ***Xysticus*** specimen in our sample is a subadult female collected in September 2009. Based on its coloration, the specimen is likely to belong to the only ***Xysticus*** species reported from the archipelago so far, the endemic ***Xysticus pigrides*** Mello-Leitão, 1929.

Other thomisid species reported by Schmidt (1999): ***Misumenops spinulosissimus***[E] (Berland, 1936).

Taxa not found in the present survey

The following additional taxa reported from Maio by Schmidt (1999) were not found in our sample: **Filistatidae:** ***Filistata canariensis*** Schmidt, 1976***;*** **Hersiliidae:** ***Hersiliola simoni*** (O. P.-Cambridge, 1872)***;*** **Miturgidae:** ***Cheiracanthium furculatum*** Karsch, 1879***,*** ***Cheiracanthium halophilum***[E] Schmidt & Piepho, 1994***;*** **Oecobiidae:** ***Oecobius navus*** Blackwall, 1859 (as ***O. annulipes***)***;*** **Pholcidae:** ***Artema atlanta*** Walckenaer, 1837***,*** ***Micropholcus fauroti*** (Simon, 1887)***,*** ***Smeringopus pallidus*** (Blackwall, 1858)***;*** **Selenopidae:** ***Selenops radiatus*** Latreille, 1819; **Theridiidae:** ***Argyrodes argyrodes*** (Walckenaer, 1841)***,*** ***Coleosoma africanum***[E] Schmidt & Krause, 1995***,*** ***Kochiura aulica*** (C. L. Koch, 1838)***,*** ***Latrodectus cinctus*** Blackwall, 1865***,*** ***Latrodectus geometricus*** C. L. Koch, 1841***,*** ***Lactrodectus*** nr. ***geometricus*** "black" (unclear status)***,*** ***Latrodectus pallidus*** O. P.-Cambridge, 1872***,*** ***Nesticodes rufipes*** (Lucas, 1846)***,*** ***Theridion cuspulatum***[E] Schmidt & Krause, 1998***,*** ***Theridion musivivoides***[E] Schmidt & Krause, 1995***,*** ***Tidarren cuneolatum*** (Tullgren, 1910) (as ***T. chevalieri***).

DISCUSSION

In agreement with earlier studies of Cape Verde spiders, the most common species in our collection are ***Berlandina nigromaculata*** (Gnaphosidae) and ***Hogna*** cf. ***ferox*** (Lycosidae). Other relatively common species are ***Pellenes*** cf. ***vanharteni*** (Salticidae), ***Zelotes laetus*** (Gnaphosidae), and ***Devade*** cf. ***indistincta*** (Dictynidae). With the exception of ***B. nigromaculata***, these species are all restricted to only one of the sampling sites, indicating rather strict habitat requirements. The remaining identified species are present mostly as singletons.

The discovery of many species that are new for Maio (10 species) or even for Cape Verde (***Devade*** cf. ***indistincta***), extending the number of known species from 36 to 46 (22% increase), is surprising in such a small collection. To some extent, this is probably due to the collection date. The most interesting species were found in September 2009, while previous visits by Schmidt and co-workers had been exclusively in spring. Also, the use of pitfall traps rather than hand collecting may have contributed to the different coverage. The latter factor is probably also responsible for the strong bias towards male specimens (42 vs. 15 specimens; 73%; the remaining 16 specimens are juveniles or subadult).

The total number of species present on Maio is probably larger. A conservative estimate (Chao1 = N_{obs} + ($N_{singletons}^2$/(2*$N_{doubletons}$)) = 16+10^2/2) predicts

66 species (Chao 1984, Colwell & Coddington 1994). Treating the checklist of Schmidt ***et al.***(1994) and the present collection as replicates (a not quite legitimate procedure), one can calculate the analogous Chao2 estimate (Chao2 = N_{total} + (N_{unique}^2/(2*N_{shared})) = 31+(11+15)^2/(2*5)), i.e. 99 species. Although the uncertainty of these estimates is quite large, the numbers do not seem unreasonably high, even considering that Maio is one of the dry and ecologically less diverse islands within Cape Verde, given that the total known number of species in the Cape Verde Islands is at least 120 (Schmidt ***et al.*** 1994, Schmidt & Krause 1998, Schmidt 1999). Considering the severe undersampling in this study (singleton frequency = 10/16 = 63%; sampling intensity = (42+15)/16 = 3.6), these numbers are possibly still underestimates of the real diversity of spiders on Maio (Coddington ***et al.*** 2009).

These estimates of total expected spider diversity agree well with the numbers reported from islands of comparable size among the northern Macaronesian archipelagos (e.g., São Jorge, Azores, 246 km^2, 54 species; El Hierro, Canary Islands, 278 km^2, 99 species; Cardoso ***et al.*** 2010). Compared to these islands, perhaps the most surprising feature of the spider fauna of Cape Verde is the absence of any spectacular evolutionary radiation, which occurred in such striking forms on the more northerly Macaronesian islands of Madeira and the Canaries (Wunderlich 1991, Arnedo ***et al.*** 2001, Dimitrov ***et al.*** 2008). The genera that are forming the most species-rich endemic complexes on Madeira and the Canary Islands are either absent (***Pholcus, Spermophorides, Lepthyphantes***) or represented by individual cosmopolitan species (***Dysdera, Oecobius***) in Cape Verde. The reason for the lack of extensive radiation of spider genera is probably the comparative homogeneity of habitats on some of the islands (Maio, Boavista, Sal), which are almost uniformly arid (Wunderlich 1991).

The largest gap in our sample concerns the family Theridiidae (comb-footed spiders): not a single one of the 10 reported species was found in our pitfall traps. This family includes some of the most interesting Cape Verdean spiders, including the dangerously venomous black-widow spiders (***Latrodectus***) and the genus ***Tidarren***, famous for the genital self-mutilation of the males (Knoflach & van Harten 2006). Similarly, Pholcidae (daddy long-leg spiders) were not recorded. The reason is probably the difference in sampling techniques, as all of Schmidt's work relied on hand collecting, while the majority of our specimens came from pitfall traps. This emphasizes the need for a diverse array of sampling methods (and times) for obtaining a comprehensive biodiversity profile of spiders (Green 1999, Sørensen ***et al.*** 2002, Borges & Brown 2003, Cardoso 2009).

With 57 adult specimens, our spider sample is small, but considering that it was obtained on a single island during a period of two months, it nonetheless compares well with the 280 specimens collected during three field seasons from eight islands by Assmuth & Groh (1982) and their co-workers. These numbers reflect the considerably lower spider densities on the arid Cape Verdean islands, compared to forest and grassland ecosystems that have previously been the focus of spider biodiversity studies (e.g. Coddington ***et al.*** 1996, Toti ***et al.*** 2000, Bell ***et al.*** 2001, Scharff ***et al.*** 2003, Cardoso ***et al.*** 2008). In a temperate European forest, the number of spider species on a single tree trunk can exceed that of many Cape Verdean islands (Blick 2011), and the number of specimens collected by an experienced collector in a single day is easily larger than our entire sample (e.g. Scharff ***et al.*** 2003). Any attempts to use spiders as indicator species for monitoring habitat quality and development in Cape Verde will need to take the much lower productivity of the semi-desert ecosystem into account. Sampling intensity has to be sufficiently low to be compatible with conservation concerns, while still being high enough to allow meaningful conclusions (Dobyns 1997).

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