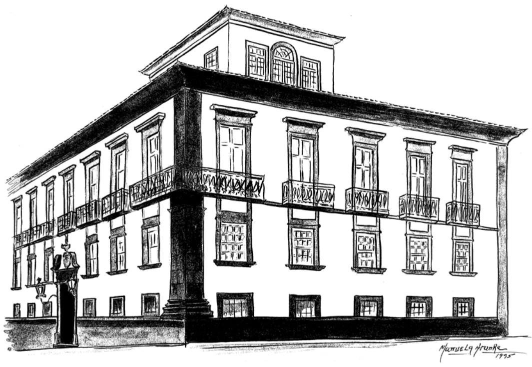

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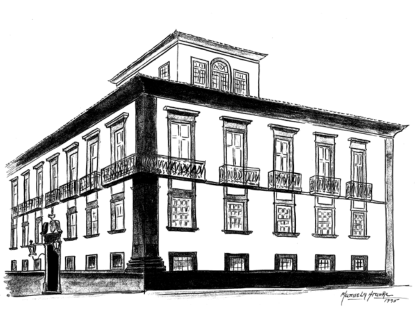

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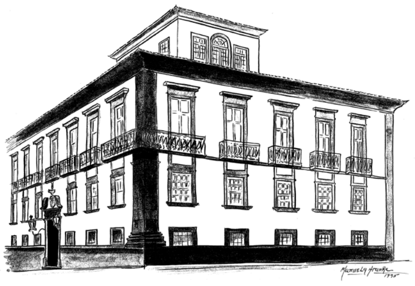

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Has *Colias hyale* (Linnaeus, 1758) ever existed in Madeira (Insecta: Lepidoptera: Pieridae)?

By Peter J. C. Russell [1 *]

With 1 plate

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ABSTRACT: The reports of the presence of *Colias hyale* from Madeira are examined and commented upon. The frequency of large populations of *Colias crocea* on the island reported by various researchers is documented. It is suggested that the museum specimens, which were observed by Burr in the collections of the *Museu de História Natural do Seminário do Funchal*, if they were of Madeiran origin, were most probably *Colias crocea* f. *cremonae*. The resemblance of *C. hyale* to this form has been reported previously and it has been recorded from Madeira more recently, when the population of *C. crocea* was abundant. Most recently, Payne considered that *C. hyale* had been recorded on Madeira. It is concluded that *C. hyale* should be removed permanently from the list of Madeiran butterflies.

Keywords: *Colias hyale*, *Colias crocea*, Madeira, Museums, Funchal.

RESUMO: Os relatos da presença de *Colias hyale* na Madeira são examinados e comentados. A frequência de grandes populações de *Colias crocea* na ilha relatada por vários investigadores é documentada. Sugere-se que os espécimes de museu, observados por Burr nas coleções do Museu de História Natural do Seminário do Funchal, se fossem de origem madeirense, seriam muito provavelmente *Colias crocea* f. *cremonae*. A semelhança de *C. hyale* com esta forma foi relatada anteriormente e foi registada na Madeira recentemente, quando a população de *C. crocea* era abundante. Mais recentemente, Payne considerou que *C. hyale* havia sido encontrada na Madeira. Conclui-se que *C. hyale* deve ser removida permanentemente da lista de borboletas madeirenses.

Palavras-chave: *Colias hyale*, *Colias crocea*, Madeira, Museus, Funchal.

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INTRODUCTION

The first published suggestion that *Colias hyale* (Linnaeus, 1758) was seen on the island of Madeira was by Cockerell (1923: 244), who reported that Dr. Malcolm Burr (no references were attached to Cockerell's article) had seen specimen(s) of *C. hyale* in the *Museu de História Natural do Seminário do Funchal*, Madeira, with the comment, 'presumably collected in Madeira'. There is no appropriate article listed by *Wikipedia* under Dr. M. Burr (accessed 16.03.2020); however, it should be noted that Burr was a specialist in Dermaptera and Orthoptera, rather than Lepidoptera. When the collection in the *Seminário* was moved to the Natural History Museum in the Funchal Botanical Gardens, Aguiar & Carvalho (2016) catalogued all the surviving insect material. No specimen of *C. hyale* was present; however, there was a pair of *C. crocea* (Geoffroy, 1875) without data (note: none of the specimens present in the Seminário had any data [Franquinho Aguiar, *pers. comm.*]). Payne (2020: 237-8 & plate 38, p. 306), solely on the basis of Cockerell's report, included *C. hyale* as a Madeiran butterfly, including a map of its 'known distribution'.

Historical references to *C. hyale* and *C. crocea* in Madeira

Baron de Worms (1964: 253) reported on his visit to Madeira in April 1964 and noted as follows: "…an area of about four acres was alive with *Colias croceus* Fourc. and I have seldom seen it more abundant in a confined space…". Swash & Askew (1982) also made a comment that *C. crocea* was the most common butterfly when they visited the island; the significance of such comments will become apparent later. Lace & Jones (1984: 163) simply recorded that *C. hyale* is a vagrant, without further comment; however, they recorded a large number of *C. crocea* along a transect at Ponta de São Lourenço between 10 and 40 m altitude. Owen *et al.* (1987: 29) merely mentioned that *C. hyale* had been reported from Madeira, without any further reference; they noted (p. 30) that in April 1985: 'at Ponta de São Lourenço dozens of *C. croceus* females were laying on clovers and vetches'. Karsholt (1988) referred to the report of *C. hyale* by Cockerell (1923), considering it doubtful; he suggested that this could have been confused with *C. crocea* f. *helice* (Hübner, 1879). Payne (2020: 237) commented upon this possibility as follows: "…it seems to this author that confusing *C. hyale* with *C. crocea* var.*helice* (sic) is too easy an explanation to try to presume – *helice* is creamy white in colour and *hyale* is bright yellow…". From this comment it is obvious that Payne was unaware that the females of *C. hyale* are always of the *alba* form, which of course are off-white in colour and thus rather similar to *C. crocea* f. *helice* (see Plate I: 1 & 3). The similarity in flight would have been notable.

Plate I – **1)** *Colias hyale* ♀, Frenois, Cote d'Or, France, 350 m, ex ovum. **2)** *Colias hyale* ♂, Frenois, Cote d'Or, France, 350 m, ex ovum. **3)** *Colias crocea* ♀ f. *helice*, Rogi, Peloponnese, Greece, 900 m. **4)** *Colias crocea* f. *cremonae* ♀, Porto do Salão, Azores, Portugal, 25 m.

Owen & Smith (1993) make no mention of *C. hyale* being part of the North Atlantic Islands butterfly fauna. Meyer (1993: 125, 129) did not include *C. hyale* in his 'checklist' of Madeiran butterflies but later, placing it in parentheses, referred to Cockerell (1923) reporting that there was specimen in the *Seminário*. Zhang (1994: 150) listed Madeira under geographical records for *C. hyale*, without further comment. Salmon & Wakeham-Dawson (1999) listed *C. hyale* as 'uncertain status', commenting later on the article of Cockerell (1923). However, they included a section on *C. crocea*, saying that it was the second most abundant butterfly in July and August 1998; they figured (plate 1, p. 79) several examples of *C. crocea*, including a male *C. crocea* f. *cremonae* Bang-Haas, 1912, to which, unfortunately, they gave the authority as Verity (see Russell *et al*., 2003) and stated that it was synonymous with 'abs *pallida* Manon, 1926, *tergestina* Stauder, 1913 and *helicinoides* Braun 1930', which are merely very pale aberrations, but still have vestiges of the red pigment present, unlike the form *cremonae*, in which it is entirely absent. This is probably the only positive record of this form from Madeira; hardly surprising since *C. crocea* populations are rarely large enough to encounter many examples of this double recessive mutant (Russell *et al*., 2003).

Wakeham-Dawson *et al*. (2001) mentioned the supposed sighting by Burr (Cockerell, 1923) and placed *C. hyale* under the heading of 'doubtful records'. Meyer (2003: 327) placed *C. hyale* in his 'Registos erróneos' list of Macaronesian species, without further comment. Wakeham-Dawson & Aguiar (2003) mentioned that *C. crocea* was common in the Funchal Ecological Park. Wakeham-Dawson, McCullough & Aguiar (2004: 113) made no comment on the record of *C. hyale*. Aguiar & Karsholt (2006: 32) placed *C. hyale* in their list of butterflies from Madeira with the following note (p. 91): "…recorded from Madeira by Cockerell (1923: 244) based on a probably unlabelled specimen that once existed in the collection of the Museu do Seminário in Funchal…" "All subsequent records of hyale from Madeira are based on this record.". Kratochwil *et al*. (2018) did not mention *C. hyale*, but summarised the works of other researchers on *C. crocea* in Madeira, mentioning the abundance of this species in some years.

DISCUSSION AND CONCLUSION

The reference to the fact that Burr had seen *C. hyale* in the *Seminário* in Funchal by Cockerell (1923) is intriguing. It is fairly obvious that the specimen(s) that Burr saw was(were) not extant when Aguiar & Carvalho (2016) catalogued the insects on their removal to the museum in the Funchal Botanical Gardens, since there was just one pair of *C. crocea* (no mention of f. *helice*). It seems very doubtful that Burr, even as a 'non-lepidopterist' would have mistaken these for *C. hyale*; surely it would have been a lemon yellow coloured butterfly that would have initiated his suggestion of *C. hyale*. It would seem likely therefore that between the times that Burr saw what he considered was *C. hyale* (certainly prior to 1923) and the cataloguing in 2016, around a century later, the reported specimens had disappeared. Maybe this was the result of infestation; butterflies are very prone to becoming a pile of dust in just a few years if left unattended.

Assuming that Burr did see something that he considered was *C. hyale*, then what are the options? It does seem very unlikely that *C. hyale* reached Madeira; the nearest populations are in northwest Spain just south of the Pyrenees, some 2000 Km away and the winds at this latitude are generally westerlies, tending to prohibit migration to the west. The present author has already refuted the wholly unscientific 'record' by Payne (2019: 153) of this species reaching the Azores Archipelago (Russell, 2020). It must be remembered that the butterflies in the *Seminário* collection originated from all over the world, there were both tropical and European specimens present (Aguiar & Carvalho, 2016), for example: *Morpho menelaus* (Linnaeus, 1758), *Aglais urticae* (Linnaeus, 1758) and *Aglais io* (Linnaeus, 1758).

Another and more probable explanation for this quandary is that, if what Burr saw did actually originate from Madeira, it was a female of *C. crocea* f. *cremonae* (see Plate I: 2 & 4). As has been shown in the Azores (Russell, Tennent & Hall, 2003), when populations of *C. crocea* flourish, this double recessive mutant form can be found in some numbers. It has been noted above, that populations of *C. crocea* on Madeira have been seen to become very extensive, often being the most abundant butterfly on the island (Swash & Askew, 1982; Owen *et al*., 1987; Salmon & Wakeham-Dawson, 1999). Thus, it would seem possible that what Burr saw was *C. crocea* f. *cremonae*, a form already recorded in Madeira and figured by Salmon & Wakeham-Dawson (1999). Payne's curious assertion (2020: 237) that the claim by Wakeham-Dawson, Salmon & Aguiar '(2000)'? (2001) that the record was doubtful 'on no evidence whatever' is nonsense. In fact, it is only Payne (2020: 237), who has accepted the 'record' of *C. hyale*, which of course it is not – it is merely a 'report' of a specimen with no data, without any positive evidence. Even in the unlikely event that the specimen(s) observed by Burr was (were) actually *C. hyale*, the fact that it had no location data precludes it (them) from being a 'record' of this species from Madeira. All of the inclusions of *C. hyale* in lists of Madeiran butterflies are based on Cockerell (1923: 244), it has never been observed since. Finally, it is concluded that the so called 'record' of *C. hyale* from Madeira is not only dubious, but entirely false and this species should be removed entirely from the list of Madeiran butterfly fauna.

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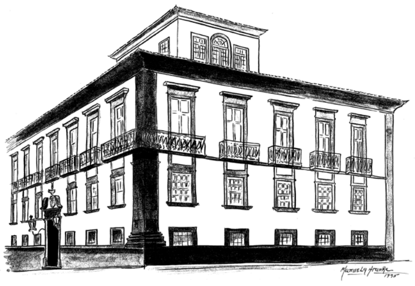

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Plant data survey in Porto Santo (Madeira Archipelago, Portugal): an update

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With 2 tables

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ABSTRACT: The present contribution updates Borges *et al*. (2008)'s "A list of the terrestrial fungi, flora and fauna of Madeira and Selvagens archipelagos". Since then, and until the summer of 2019, 131 new taxa were cited, namely 30 bryophytes, one pteridophyte and 100 spermatophytes.

Based on the compilation of written and unpublished information about the diversity of terrestrial plants cited for Porto Santo, the present work lists 696 taxa, including 134 bryophytes, 13 pteridophytes and 549 spermatophytes.

Two species of mosses, *Sematophyllum substrumulosum* (Hampe) E. Britton and *Tortula lanceolata* R. H. Zander are recorded for the first time from Porto Santo, corresponding to material collected in 2018.

Additionally, 12 species of spermatophytes, all cultivated, are referred for the first time to the island. Two species of pteridophytes, *Ophioglossum lusitanicum* L. and *Hymenophyllum wilsonii* Hook are proposed to be considered extinct.

Keywords: agrodiversity, bryophytes, crop wild relatives, pteridophytes, spermatophytes.

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RESUMO: O presente trabalho atualiza a publicação "A list of the terrestrial fungi, flora and fauna of Madeira and Selvagens archipelagos" (Borges *et al*., 2008). Após essa publicação e até ao verão de 2019, foram citados 131 novos táxones, nomeadamente 30 briófitos, um pteridófito e 100 espermatófitos.

Tendo por base a compilação de informação escrita e não publicada sobre a diversidade de plantas terrestres citadas para o Porto Santo, neste trabalho são referidos 696 táxones, incluindo 134 briófitos, 13 pteridófitos e 549 espermatófitos.

Duas espécies de musgos, *Sematophyllum substrumulosum* (Hampe) E. Britton e *Tortula lanceolata* R. H. Zander são referidas pela primeira vez para o Porto Santo, correspondendo a material recolhido em 2018.

Adicionalmente, 12 espécies de espermatófitos, todos cultivados, são referidos pela primeira vez para a ilha. Duas espécies de pteridófitos, *Ophioglossum lusitanicum* L. e *Hymenophyllum wilsonii* Hook são propostos como extintos.

Palavras-chave: agrobiodiversidade, briófitos, parentes silvestres de cultivares, pteridófitos, espermatófitos.

INTRODUCTION

Porto Santo is an eastern Atlantic Ocean island, about 40 km to the NE of Madeira; it developed as a submarine shield volcano, dating from 18-14.5 Ma, and presents an emerged area of 42 km^2 (Mata *el al*., 2013).

The island of Porto Santo, 12 km long in the NE-SW direction and 6 km wide, in the N-S direction, has a flat and smooth morphology, with Pico do Facho standing out with a maximum altitude of 517 m. This island is surrounded by six islets – Ilhéu de Baixo, Ilhéu de Cima, Ilhéu de Ferro, Ilhéu da Fonte da Areia, Ilhéu das Cenouras, Ilhéu de Fora, and two rocky outcrops – Baixa do Meio and Baixa dos Barbeiros.

During its early geological phase, the territory was colonized by pioneer species, such as lichens and nonvascular plants (*i.e*., bryophytes). Together with other living beings, these species contributed to the formation of soil layers able to progressively sustain more complex communities, eventually reaching the forest ecosystem structure.

Over thousands of years, natural phenomena of expansion and competition probably occurred, dictating the evolution of a biodiversity in absence of human influence, until the beginning of settlement by the Portuguese, in the first quarter of the 15th century.

The first reference to the plants of Porto Santo is by Luiz de Cadamosto, who visited Porto Santo in 1455 and mentions the dragon tree, *Dracaena draco* L. and its uses by the local population (Cadamosto, 1867).

Since then, several works have been published, the information of which was included in "A list of the terrestrial fungi, flora and fauna of Madeira and Selvagens archipelagos" by Borges *et al.* (2008). These authors compiled the published information on the biodiversity of Porto Santo, as well as of the islands of Madeira, Desertas and Selvagens. They consider taxa down to the subspecies rank recognized in primary publications until 2008, and thus list for Porto Santo 104 bryophytes, comprising four hornworts, 60 liverworts and 40 mosses (Sérgio *et al*., 2008; in Borges *et al*., 2008), 13 pteridophytes and 450 spermatophytes (Jardim & Sequeira, 2008; in Borges *et al*., 2008).

More than 18 years later, new papers, reports and other works have been published, such as the application of the Island of Porto Santo to the UNESCO Biosphere Reserve (2019), which addresses aspects of the plant cover of the island and refers new records and taxa for science.

Among the works published after 2008 about vascular flora, the following are worth highlighting: Carvalho *et al*. (2010), Carvalho *et al*. (2013), Fernandes & Carvalho (2014), Jardim & Sequeira (2010), Jardim & Sequeira (2011a), Jardim & Sequeira (2011b), Jardim & Sequeira (2011c), Jardim & Sequeira (2014), and Jones *et al*. (2014). Regarding bryophytes, the following works are worth mentioning: Lobo (2008), Sim-Sim *et al*. (2010), and Fontinha *et al*. (2012).

MATERIAL AND METHODS

The published and reported information about bryophytes, pteridophytes and spermatophytes in Porto Santo was compiled, and unpublished information was collected.

In addition to the bibliography, the database of Information and Documentation System (IDS) of ISOPlexis Genebank, University of Madeira (ISOPlexis GRIN-Global) was consulted, concerning agrodiversity (cultivated species) and crop wild relatives.

Complementary inventories were carried out, in order to confirm the presence of taxa and update the existing information.

Infraspecific taxonomic categories referring to subspecies and variety were considered; hybrids were not taken into account.

In general, taxonomy and nomenclature for nonvascular plants follow Sérgio *et al*. (2008), whereas for vascular plants they follow Jardim & Sequeira (2008).

RESULTS

According to the accomplished compilation, 696 taxa of terrestrial plants are recorded from Porto Santo, 134 of which correspond to bryophytes (four hornworts, 68 liverworts and 62 mosses), 13 are pteridophytes and 549 are spermatophytes.

The list of Borges *et al*. (2008) was used as a base-line information source, to which 131 new taxa, comprising 30 bryophytes (Table 1), one pteridophyte (*Asplenium onopteris* L.) and 100 spermatophytes (Table 2) reported in the subsequent 12 years were added.

DISCUSSION

Concerning bryophytes, nine species of liverworts and 21 species of mosses are mentioned, including two Madeira endemics (*Frullania sergiae* Sim-Sim, S. Fontinha, R. Mues & U. Lionand and *Riccia atlantica* Sérgio & Perold). Two species of mosses, *Sematophyllum substrumulosum* (Hampe) E. Britton and *Tortula lanceolata* R. H. Zander are recorded for the first time from Porto Santo, corresponding to material collected in 2018.

Among pteridophytes, *Asplenium onopteris* L. is recorded for the first time from Porto Santo and considered a native species. *Ophioglossum lusitanicum* L., cited by Costa for Porto Santo between 1938-1941, as stated by Pickering (1962), has never been observed again in nature, and we propose to consider it extinct. The same is proposed for *Hymenophyllum wilsonii* Hook, a species that was considered as doubtful by Jardim & Sequeira (2008), and that has not been observed in nature over the last 12 years.

Regarding spermatophytes, 100 taxa are mentioned; eight of them are Porto Santo endemics (*Echium portosanctense* J. A. Carvalho, Pontes, Batista-Marques & R. Jardim; *Fumaria muralis* Sond. ex W. D. J. Koch subsp. *muralis* var. *laeta*; *Helichrysum melaleucum* Rchb. subsp. roseum (Lowe) R. Jardim & M. Seq.; *Lotus glaucus* Aiton subsp. *floridus* (Lowe) R. Jardim & M. Seq.; *Monizia edulis* Lowe subsp. *santosii* F. Fernandes & J. A. Carvalho; *Sideritis candicans* Aiton var. *multiflora*; *Sonchus parathalassius* J. G. Costa ex R. Jardim & M. Seq.; *Pericallis menezesii* R. Jardim, K. E. Jones, M. Carine & M. Sequeira), three species are Madeira endemics [*Carduus squarrosus* (DC.) Lowe; *Rubia fruticosa* Aiton subsp. *fruticosa* and *Sibthorpia peregrina* L.] and one is a Macaronesia endemic (*Laurus novocanariensis* Rivas Mart. *et al*.).

Borges *et al*. (2008) refer *Siderites candicans* for Porto Santo, but not the *multiflora* variety that is endemic to that island. The same happens with *Fumaria muralis* Sond. ex W. D. J. Koch, and its subspecies *muralis* variety *laeta*, endemic to Porto Santo; *Helichrysum melaleucum*, and its subspecies *roseum* described by Jardim & Sequeira (2011c); *Lotus glaucus*, and its subspecies *floridus* described by Jardim & Sequeira (2011a); and *Monizia edulis*, and its subspecies *santosii*, described by Fernandes & Carvalho (2014). The laurel tree, *Laurus novocanariensis*, occurred naturally in Porto Santo (Sousa, 2005), but it became extinct and was afterwards reintroduced.

As for agrodiversity, 32 taxa are reported, corresponding to locally grown crops and its varieties such as: garlic (*Allium sativum* L.), onion (*Allium cepa* L.), strawberry tree (*Arbutus unedo* L.), oats (*Avena sativa* L.), chard [*Beta vulgaris* subsp. *cicla* (L.) W. D. J. Koch], borage (*Borago officinalis* L.), pepper [*Capsicum baccatum* L. var. *pendulum* (Willd.) Eshbaugh], locust bean (*Ceratonia siliqua* L.), watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai], melon (*Cucumis melo* L.), cucumber (*Cucumis sativus* L.), pumpkin (*Curcubita maxima* Duchesne, C. *moschata* Duchesne ex Poir., *C. pepo* L.), carrot (*Daucus carota* L.), barley (*Hordeum vulgare* L.), pitaia [*Hylocereus undatus* (Haworth) Britton & Rose], sweet potato [*Ipomoea batatas* (L.) Lam.], grass pea (*Lathyrus sativus* L.), apple tree [*Malus domestica* (Borkh.) Borkh.], mulberry (*Morus nigra* L.), olive tree (*Olea europaea* L.), Lima bean (*Phaseolus lunatus* L.), common beans (*Phaseolus vulgaris* L.), date palm (*Phoenix dactylifera* L.), peas (*Pisum sativum* L.), peach tree [*Prunus persica* (L.) Batsch], pear tree (*Pyrus communis* L.), potato (*Solanum tuberosum* L.), wheat (*Triticum aestivum* L.), vine (*Vitis vinifera* L.) and corn (*Zea mays* L.).

To these species, 14 crop wild relatives (CWR) are added, of which four endemic taxa of Porto Santo: *Helichrysum melaleucum* subsp. *roseum*, *Lotus glaucus* subsp. *floridus*, *Monizia edulis* subsp. *santosii* and *Sonchus parathalassius*.

Table 1 – Update of the list of bryophytes reported by Sérgio *et al.* (2008).

	Taxon	**Reference**
L, N	*Asterella africana* (Mont.) A. Evans.	Sim-Sim *et al.* (2010)
M, N	*Brachythecium rutabulum* var. *atlanticum* Hedenäs	Lobo (2008)
M, N	*Bryum caespiticium* Hedw.	Lobo (2008)
M, N	*Bryum capillare* Hedw.	Lobo (2008)
M, N	*Bryum radiculosum* Brid.	Lobo (2008)
M, N	*Campylopus brevipilus* Bruch & Schimp	Sim-Sim *et al.* (2010)
M, N	*Ceratodon purpureus* (Hedw.) Brid.	Sim-Sim *et al.* (2010)
M, N	*Entosthodon obtusus* (Hedw.) Lindb.	Sim-Sim *et al.* (2010)
M, N	*Epipterygium tozeri* (Grev.) Lindb.	Lobo (2008)
L, N	*Fossombronia caespitiformis* De Not. ex Rabenh.	Lobo (2008)
L, N	*Fossombronia husnotii* Corb.	Lobo (2008)
L, MAD	*Frullania sergiae* Sim-Sim, S. Fontinha, R. Mues & U. Lion	Lobo (2008)
M, N	*Grimmia trichophylla* Grev.	Lobo (2008)
M, N	*Hymenostylium recurvirostrum* (Hedw.) Dixon	Lobo (2008)
M, N	*Hypnum cupressiforme* var. *resupinatum* (Hedw.) Dixon	Lobo (2008)
M, N	*Kindbergia praelonga* (Hedw.) Ochyra	Lobo (2008)
M, N	*Leptophascum leptophyllum* (Müll. Hal.) J. Guerra & M. J. Cano	Sim-Sim *et al.* (2010)
M, N	*Leucodon treleasei* (Cardot) Paris	Lobo (2008)
L, N	*Lophocolea bidentata* (L.) Dumort.	Lobo (2008)
L, N	*Lophocolea minor* Nees	Lobo (2008)
M, N	*Microbryum starckeanum* (Hedw.) R. H. Zander	Lobo (2008)
M, N	*Oedipodiella australis* (Wager & Dixon) Dixon	Sim-Sim *et al.* (2010)
M, N	*Pleuridium subulatum* (Hedw.) Rabenh.	Lobo (2008)
L, MAD	*Riccia atlantica* Sérgio & Perold	Sim-Sim *et al.* (2010)
L, N	*Riccia crozalsii* Levier	Lobo (2008)
M, N	*Sematophyllum substrumulosum* (Hampe) E. Britton	NR
L, N	*Targionia lorbeeriana* Müll. Frid.	Sim-Sim *et al.* (2010)
M, N	*Tortula lanceolata* R. H. Zander	NR
M, N	*Trichostomum brachydontium* Bruch	Lobo (2008)
M, N	*Zygodon rupestris* Schimp. ex Lorentz	Lobo (2008)

L – Liverwort; M – Moss; MAD – Madeira Endemic; N – Native; NR – New Record.

Table 2 – Update of the list of pteridophytes and spermatophytes reported by Jardim & Sequeira (2008).

	Taxon	**Reference**
I	*Agave americana* L.	Carvalho *et al.* (2013)
I	*Achyranthes sicula* (L.) All.	Jardim & Sequeira (2014)
I	*Agapanthus praecox* Willd. subsp. *Orientalis* (F. M. Leight) F. M. Leight	Jardim & Sequeira (2014)
I	*Allium sativum* L.	ISOPlexis GRIN-Global
I	*Allium cepa* L.	NR
I	*Aloe arborescens* Mill.	Abreu *et al.* (2008)
I	*Amaryllis belladona* L.	Jardim & Sequeira (2011c)
NP	*Anchusa azurea* Mill.	Jardim & Sequeira (2014)
I	*Arbutus unedo* L.	Jardim & Sequeira (2014)
C	*Asparagus aethiopicus* L.	Jardim & Sequeira (2014)
P, N	*Asplenium onopteris* L.	NR
I	*Atriplex semibaccata* R. Br.	Jardim & Sequeira (2014)
I	*Avena sativa* L.	NR
I	*Beta vulgaris* subsp. *cicla* (L.) W. D. J. Koch	NR
I	*Borago officinalis* L.	NR
I	*Bromus catharticus* Vahl	Jardim & Sequeira (2011c)
I	*Capsicum baccatum* L. var. *pendulum* (Willd.) Eshbaugh	NR
MAD	*Carduus squarrosus* (DC.) Lowe	Jardim & Sequeira (2014)
I	*Ceratonia siliqua* L.	Sødergaard, P. (1995)
I	*Chamaesyce serpens* (Kunth) Small	Jardim & Sequeira (2014)
I	*Chasmanthe aethiopica* (L.) N. E. Br.	Jardim & Sequeira (2014)
I	*Citrullus lanatus* (Thunb.) Matsum. & Nakai	ISOPlexis GRIN-Global
I	*Conyza sumatrensis* (Retz.) E. Walker	Jardim & Sequeira (2014)
I	*Cotyledon orbiculata* L.	Jardim & Sequeira (2011c)
I	*Cucumis melo* L.	NR
I	*Cucumis sativus* L.	NR
I	*Cupressus macrocarpa* Hartw.	Jardim & Sequeira (2011c)
I	*Curcubita maxima* Duchesne	ISOPlexis GRIN-Global
I	*Curcubita moschata* Duchesne ex Poir.	ISOPlexis GRIN-Global
I	*Curcubita pepo* L.	ISOPlexis GRIN-Global
I	*Cydonia oblonga* Mill.	ISOPlexis GRIN-Global
C, I	*Cyperus eragrostis* Lam.	Abreu *et al.* (2008)
C, I	*Cyperus involucratus* Rottb.	Jardim & Sequeira (2014)
I	*Cytisus striatus* (Hill) Rothm.	Jardim & Sequeira (2014)
I	*Daucus carota* L.	NR
I	*Digitaria ciliaris* (Retz.) Koeler	Jardim & Sequeira (2014)
I	*Digitaria sanguinalis* (L.) Scop.	Jardim & Sequeira (2014)
I	*Diplotaxis tenuifolia* (L.) DC.	Jardim & Sequeira (2014)
IP	*Dittrichia viscosa* (L.) Greuter	Jardim & Sequeira (2014)
I	*Dodonaea viscosa* (L.) Jacq.	Jardim & Sequeira (2014)
E	*Echium portosanctense* J. A. Carvalho, Pontes, Batista-Marques & R. Jardim	Carvalho *et al.* (2013)

Table 2 (continued).

	Taxon	**Reference**
I	*Eucalyptus robusta* Sm.	Jardim & Sequeira (2014)
I	*Euphorbia ingens* E. Mey.	Abreu *et al.* (2008)
E	*Fumaria muralis* Sond. ex W. D. J. Koch subsp. *muralis* var. *laeta*	Jardim *et al.* (1998)
I	*Galinsoga parviflora* Cav.	Jardim & Sequeira (2014)
I	*Galinsoga quadriradiata* Ruiz & Pav.	Jardim & Sequeira (2014)
N	*Gastridium ventricosum* (Gouan) Schinz & Thell	Jardim *et al.* (2003)
C, E	*Helichrysum melaleucum* Rchb. subsp. *roseum* (Lowe) R. Jardim & M. Seq.	Jardim & Sequeira (2011c)
I	*Hibiscus rosa-sinensis* L.	Abreu *et al.* (2008)
I	*Hordeum vulgare* L.	ISOPlexis GRIN-Global
I	*Hylocereus undatus* (Haworth) Britton & Rose	ISOPlexis GRIN-Global
I	*Ipomoea batatas* (L.) Lam.	ISOPlexis GRIN-Global
C, I	*Ipomoea pes-caprae* (L.) R. Br.	Jardim & Sequeira (2014)
I	*Lampranthus multiradiatus* (Jacq.) N. E. Br	Abreu *et al.* (2008)
I	*Lantana camara* L.	Jardim & Sequeira (2014)
I	*Lathyrus sativus* L.	ISOPlexis GRIN-Global
MAC	*Laurus novocanariensis* † Rivas Mart. Lousa, Fern. Prieto, E. Dias, J. C. Costa & C. Aguiar	NR
I	*Lepidium virginicum* L.	Jardim & Sequeira (2014)
C, E	*Lotus glaucus* Aiton subsp. *floridus* (Lowe) R. Jardim & M. Seq.	Jardim & Sequeira (2011a)
I	*Malephora crocea* (Jacq.) Schwantes var. *crocea*	Jardim & Sequeira (2014)
I	*Malus domestica* (Borkh.) Borkh.	ISOPlexis GRIN-Global
C, IP	*Medicago lupulina* L.	Jardim & Sequeira (2014)
C, I	*Medicago sativa* L.	Jardim & Sequeira (2014)
C	*Mercurialis annua* L.	Carvalho *et al.* (2013)
I	*Metrosideros excelsa* Sol. ex Gaertn.	Jardim & Sequeira (2014)
C, E	*Monizia edulis* Lowe subsp. *santosii* F. Fernandes & J. A. Carvalho	Fernandes & Carvalho (2014)
I	*Morus nigra* L.	Abreu *et al.* (2008)
I	*Myoporum laetum* G. Forst.	Carvalho *et al.* (2013)
I	*Morella faya Aiton*	NR
I	*Nerium oleander* L.	Abreu *et al.* (2008)
I	*Nicandra physalodes* (L.) Gaertn.	Jardim & Sequeira (2011c)
I	*Olea europaea* L.	Brito (2009)
I	*Opuntia subulata* (Muehlenpf.) Engelm	Jardim & Sequeira (2014)
N	*Orobanche ramosa* L. subsp. *nana* (Reut.) Cout.	Carvalho *et al.* (2013)
I	*Oxalis debilis* Kunth	Jardim & Sequeira (2014)
I	*Paspalum dilatatum* Poir.	Jardim & Sequeira (2011c)
I	*Passiflora edulis* Sims	ISOPlexis GRIN-Global
I	*Pennisetum purpureum* Schum.	Jardim & Sequeira (2014)
E	*Pericallis menezesii* R. Jardim, K. E. Jones, M. Carine & M. Sequeira	Jones *et al.* (2014)
I	*Phaseolus lunatus* L.	ISOPlexis GRIN-Global

Table 2 (continued).

	Taxon	Reference
I	*Phaseolus vulgaris* L.	NR
I	*Phoenix dactylifera* L.	Abreu *et al.* (2008)
I	*Pisum sativum* L.	ISOPlexis GRIN-Global
IP	*Poa trivialis* L.	Jardim & Sequeira (2014)
I	*Prunus persica* (L.) Batsch	ISOPlexis GRIN-Global
I	*Pyrus communis* L.	ISOPlexis GRIN-Global
I	*Quercus ilex* L.	Abreu *et al.* (2008)
MAD	*Rubia fruticosa* Aiton subsp. *fruticosa*	Jardim & Sequeira (2014)
N	*Ruppia maritima* L.	Jardim & Sequeira (2011c)
C, I	*Senecio angulatus* L.f.	Jardim & Sequeira (2011c)
I	*Setaria parviflora* (Poir.) Kerguélen	Jardim & Sequeira (2014)
MAD	*Sibthorpia peregrina* L.	Jardim & Sequeira (2011c)
E	*Sideritis candicans* Aiton var. *multiflora*	Francisco & Jardim (2000)
C, I	*Solanum mauritianum* Scop.	Jardim & Sequeira (2014)
I	*Solanum tuberosum* L.	NR
C, E	*Sonchus parathalassius* J. G. Costa ex R. Jardim & M. Seq.	Jardim & Sequeira (2011b)
C, IP	*Taraxacum officinale* Weber	Jardim & Sequeira (2014)
I	*Triticum aestivum* L.	ISOPlexis GRIN-Global
I	*Vicia faba* L.	ISOPlexis GRIN-Global
I	*Vitis vinifera* L.	Abreu *et al.* (2008)
I	*Zea mays* L.	ISOPlexis GRIN-Global

C – Crop wild relative; E – Porto Santo Endemic; I – Introduced; IP – Possible Introduced; MAC – Macaronesia Endemic; MAD – Madeira Endemic; N – Native; NP – Possible Native; NR – New Record; P – Pteridophyte; † – Extinct.

This paper is important for decision-makers and management and nature conservation officials, especially when Porto Santo is being proposed as a UNESCO Biosphere Reserve.

Note added at proof-reading: Porto Santo was designated as UNESCO Biosphere Reserve in October 2020.

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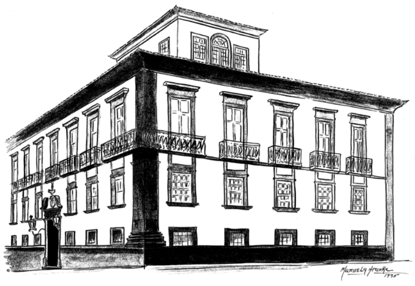

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First record of an ‘Alba’ male in the supposed female sex-limited ‘Alba’ polymorphism of *Colias croceus* (Geoffroy in Fourcroy, 1785) (Lepidoptera, Pieridae)

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With 2 figures

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ABSTRACT: Within the scope of a butterfly survey on Porto Santo (Madeira Archipelago, Portugal), an ‘Alba’ male of *Colias croceus* was detected and collected. Although older literature sources report occurrences of rare ‘Alba’ colour morphs in males of other *Colias* species, for example, in *C. philodice*, recent publications consider the colour polymorphism of *C. croceus* to be strictly limited to females. The detected ‘Alba’ male of *C. croceus* will be described. The assumption that the ‘Alba’ polymorphism is based on a simple Mendelian inheritance in which sex determination and colour polymorphism are in complete genetic linkage is doubtful.

Keywords: Lepidoptera, *Colias croceus*, *Colias philodice*, colour morphs in males, Porto Santo, Madeira Archipelago, sex determination.

RESUMO: No âmbito de uma pesquisa de borboletas no Porto Santo (Arquipélago da Madeira, Portugal), foi detetado e coletado um macho ‘Alba’ de *Colias croceus*. Embora fontes mais antigas da literatura relatem ocorrências de raras formas de coloração ‘Alba’ em machos de outras espécies de *Colias*, por exemplo, em *C. philodice*, publicações recentes consideram o polimorfismo de cores de *C. croceus* estritamente limitado às fêmeas. O macho ‘Alba’ de *C. croceus* detetado é descrito. A suposição de que o polimorfismo ‘Alba’ é baseado em uma simples herança mendeliana, na qual a determinação do sexo e o polimorfismo da cor estão em completa ligação genética, é duvidosa.

Palavras-chave: Lepidoptera, *Colias croceus*, *Colias philodice*, formas de coloração nos machos, Porto Santo, Arquipélago da Madeira, determinação do sexo.

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INTRODUCTION

About one-third of the approximately 90 species within the genus *Colias* (Lepidoptera, Pieridae) show a distinct pigment polymorphism in the female butterflies (Remington, 1954; Limery & Morehouse, 2016). Apart from the typically yellow / orange-coloured females, whitish-coloured females occur. In *C. croceus*, this form had been described as f. *helice* Hübner, 1779. Such forms are generally called 'Alba' forms. According to Remington (1954), this 'Alba' polymorphism is based on a simple Mendelian inheritance controlled by a single locus with two alleles, transmitted autosomally by both sexes, and dominant in the female but never expressed at all by males. Females which carry the dominant allele '*A*' have white wings, and homozygous recessive '*aa*' females exhibit yellow / orange wings like conspecific males. The phenotypes of males should therefore not show this 'Alba' polymorphism. Gerould (1911), Goldschmidt (1912), Hovanitz (1950), and Remington (1954) emphasised that this phenotypic manifestation is strictly 'sex-controlled'.

Lorkovics & Herman (1961) pointed out that white males in *C. croceus* do not occur, neither in nature nor in butterfly breeding experiments. Also, in recent publications concerning *C. croceus* (*e.g.*, Woronik & Wheat, 2017; Woronik *et al.*, 2018a, 2018b, 2019), the occurrence of 'Alba' forms in males had not been mentioned. In all these investigations, it is assumed that two colour morphs in females and one colour morph in males occur and that 'Alba' forms do not exist in males. The maintenance of the two female morphs is based on a balanced polymorphism. Woronik & Wheat (2017) identified the locus that causes the colour polymorphism in *C. croceus*. Further aspects on physiology and life-history strategies as well as further investigations on the genetic basis of this polymorphism can be found in Woronik *et al.* (2018a, 2018b, 2019) and provide conclusive and remarkable results. In all these publications, however, the occurrence of male 'Alba' forms in *C. croceus* is not discussed.

The phenomenon of colour polymorphism in the *Colias* species with two different female colour morphs (orange / white) and one male colour morph (orange) was first detected by Gerauld (1911) for *C. philodice* (Godart, 1819). Later, this could also be demonstrated for other *Colias* species for North America (*C. eurytheme* (Boisduval, 1852); *C. interior* (Scudder, 1862); *C. christina* W. H. Edwards, 1863) and for Europe (*C. edusa* (Geoffroy in Fourcroy, 1785); *C. myrmidone* (Esper, 1780); *C. hyale* (Linnaeus, 1758)); see Gerould (1923) and Remington (1954).

Gerould (1911) pointed out for *C. philodice* that white males can occur in extremely rare cases. The author expected white males especially in areas with a particularly high number of white females (around 50%). One white male of *C. philodice* was observed in nature by W. L. W. Field (Gerould, 1911). Initially, 'Alba' forms in males were interpreted as recessive homozygotes, but they never appeared in breeding experiments ('among the 900 descendants of white females that I have raised, there has been not one white male'; Gerould, 1911). Gerould (1923) interpreted the white males as the result of a mutation in which the orange colouring is replaced by white pigments. According to Goldschmidt (1912), white males of *C. philodice* are only present after mutation, regardless of the genes that determine the colouration of the females. The possibility of a spontaneous loss of melanic colour (amelanism), yellow / orange colour (axanthism), or both (albinism) should be considered.

In the recent past, a white male of *C. philodice* was collected in West Lafayette, Tippecanoe County, Indiana, USA, by Alex Bic (16 September 2010), and a photo was published on the internet platform BugGuide on 4 April 2011 (http://bugguide.net/node/view/503074). However, no evidence of a male 'Alba' form in *C. croceus* was found in the literature.

MATERIAL AND METHODS

Porto Santo (42 km^2) is of volcanic origin, with an age of about 11.1 to 14.3 Ma, and is located about 40 km north-east of Madeira Island (Geldmacher *et al.*, 2000), separated by an ocean bed with more than 2,000 m depth. The highest peak is the Pico do Facho (517 m *a.s.l.*), geologically (as well as other summits of the island) mainly characterised by trachytic and basaltic structures. About one-third of the island is covered with quaternary sediments. According to Rivas-Martínez (2009), the bioclimate is classified as Mediterranean xeric-oceanic with significant summer aridity. Only the highest regions have a mesic xeric bioclimate.

The butterfly species (Papilionoidea) of Porto Santo (10 species, 204 individual observations) were mapped during visits in 2012 (16-20 March) and 2017 (19-31 March) by A. Kratochwil and A. Schwabe (Kratochwil *et al.*, 2018) on the basis of 1 km x 1 km grids. The 45 sites reflect the most important habitat types of the island (Kratochwil & Schwabe, 2018). Our observations demonstrated that *C. croceus* is quite common throughout Porto Santo from sea level up to the highest mountains (38 sites; Figure 1 in Kratochwil *et al.*, 2018). *C. croceus* is euryanthic and could be detected on the flowers of 10 plant species belonging to 7 plant families (Kratochwil *et al.*, 2018).

RESULTS AND DISCUSSION

In the course of the butterfly monitoring, 77 detections of *C. croceus* were made. Among them, an 'Alba' female and an 'Alba' male were detected. Figure 1 shows the female orange form and the female white form of *C. croceus*. The hind wings of the 'Alba' female are dark coloured. Figure 2 shows an orange male and the detected 'Alba' male. The lower part of the forewing of the 'Alba' male and the basal part of the hind wing are characterised by a slightly orange tinge. The hind wings are dark coloured, similar to the 'Alba' form of the female. The sex can also be provided by the conspicuous scent scales (androconia) near the wing base in cell 7 of the hind wings, which are restricted to males (Fig. 2). In addition, aberrations of *C. croceus* females where the yellow spots are missing in the black outer band (ab. *pseudomas* Cockerell, 1889) as well as '*helice*' forms of ab. *pseudomas* (ab. *nigra* Aigner, 1906) were described; see Grieshuber & Lamas (2007).

Aguiar & Karsholt (2006) reported that *C. croceus* females var. *helice* (Hübner, 1879) were frequently seen on Porto Santo (5%-10% of all populations). In the Museu de História Natural do Funchal, three females of the form '*helice*' are deposited, collected in May 1942 (unknown collector, determined by J. T. Smit in 1998), as well as two females of the same form, collected on 30 March 1988 by F. Zino (determined by J. T. Smit in 1998).

A classification of *C. croceus* into pure orange and pure white colour morphs in females is not always possible in this strict manner. Usually, the name 'Alba' or form '*helice*' in the broader sense includes all bright forms (white to yellowish wing colours). *C. croceus* shows specimens of different colour intensities and colour tones throughout its distribution area, which had been listed as forms, varieties, and aberrations. Grieshuber & Lamas (2007) mentioned 120 aberrations, 40 forms, and 7 varieties for *C. croceus*, which had been described and published by different authors. Although the International Code of Zoological Nomenclature does not consider names below the subspecies level, such forms, varieties, and aberrations are elements of the phenotypic variability of a taxon. Even if one has to assume that homonyms are among them, excluding homonyms should be possible in many cases. Usually, in the case of *C. croceus*, these differences are shown in the colour of the wings. Such wing colour patterns, based on phenotypic plasticity, may be produced physiologically in response to environmental stress (*e.g.*, temperature, general stress response) and may also be genetically fixed in a population (Otaki *et al.*, 2010). This was shown particularly for the genus *Vanessa* (Hiyama *et al.*, 2012).

In the Madeira Archipelago, *C. croceus* females occur in numerous varieties (Salmon & Wakeham-Dawson, 1999), all of which are characterised by different colouration: for example, var. *cremonae* Verity, 1911; var. *dawsoni* Bollow, 1930; var. *geisleri* Bryk, 1923; var. *radiata* Nitsche, 1932; and var. *faillae* Stefanelli, 1900.

Limeri & Morehouse (2016) indicated that the ancestor of the Coliadinae was already polymorphic and that 'Alba' polymorphisms occurred. The Coliadinae include 203 taxa, and about half of the species are polymorphic in females (46%). In some cases, this polymorphism has repeatedly given rise to a monomorphism. The repeated loss of the polymorphism indicates that the 'Alba' polymorphism has a certain evolutionary instability (Limeri & Morehouse, 2016; Jamie & Meier, 2020).

Many studies have been carried out on the 'Alba' polymorphism in *Colias*. Descimon (1966) and Watt (1973) discovered the origin of the colour change by analysing the underlying differences in pteridine wing pigment synthesis. Graham *et al.* (1980) and Gilchrist & Rutowski (1986) found, for instance, different metabolism rates and fat body sizes as well as analysed the fecundity rates, the number of eggs per day, the survival probabilities of the eggs, and the lifespan lengths while comparing the two female colour morphs. They pointed out that concerning these parameters, the white colour morph in females is selectively advantageous compared with the orange morph. 'Alba' females may also benefit from their mimetic and cryptic colouration towards predators (Gilchrist & Rutowski, 1986). Nevertheless, white butterflies are not always advantageous in selection because certain biotic and abiotic factors have contrast-selective effects (Hovanitz, 1950; Nielsen & Watt, 2000). Thus, white females are less attractive to males (Graham *et al.*, 1980), and males show less courtship persistence with white females (Marshall, 1982). The transfer of nutrients by spermatophores is also much lower in 'Alba' females than in yellow / orange females, owing to the lower number of mating males (Boggs & Watt, 1981). In particular, if other white butterfly species are present, this would be unfavourable for partner interactions of these *Colias* species. In mark-releaserecapture experiments, Gilchrist & Rutowski (1986) showed in *C. eurytheme* that 'Alba' females have longer residence times than orange females who emigrate for reasons of male harassment.

The two female colour morphs show different temperature-dependent development rates (Graham *et al*., 1980; Nielsen & Watt, 2000). Thus, 'Alba' forms in females of *C. croceus* have higher fitness under cold conditions, orange forms under warm conditions (Woronik *et al*., 2018a). 'Alba' phenotypes are more common in the distribution area of their species in the northern parts or at higher altitudes (Gerauld, 1923; Hovanitz, 1944a, 1944b, 1950; Remington, 1954) of the region. In contrast, 'Alba' females absorb less solar heat than orange females and avoid overheating (Watt, 1973; Kingsolver, 1983; Kingsolver & Watt, 1983).

There exists no doubt that in the case of *C. croceus*, 'Alba' forms can also exist in males. However, the interrelationships here seem to be much more complicated than previously assumed in the literature. The question arises of whether comparable examples exist in other animal groups and, if so, what solutions occur.

Cichlid fishes form a model system in which colour polymorphism has been studied in detail for vertebrate taxa. For example, a cryptic morph can be commonly observed in female cichlid fishes (Roberts *et al*., 2009). In rare cases, such polymorphisms are also found in male fishes, where they, however, disrupt the nuptial colouration. This scenario creates a sexual conflict as the polymorphism constitutes a selective advantage for females (camouflage) and a disadvantage for males (nuptial signal). According to Roberts *et al*. (2009), this sexual conflict is resolved by a strong linkage between the colour polymorphism locus and a novel sex-determining locus.

If these findings are compared with those of *C. croceus*, similar relationships might be found. The polymorphism will usually be accompanied by considerable advantages for the females. In *Colias*, for instance, adaptations to different climatic conditions and metabolic performance are influenced by these conditions. In the males, however, polymorphism makes little sense because only the orange phenotype seems essential for mating behaviour. Male UV colouration in *C. eurytheme* and other sulphurs, for example, *C. croceus*, is important for species recognition and sexual identification (Silberglied & Taylor, 1978; Rutowski, 1985). The wings of the males and females of *C. eurytheme* contain the pteridine pigments described by Watt (1964, 1967): xanthopterin (yellow), leucopterin (colourless), sepiapterin (yellow / orange), and erythropterin (red). Compared with the yellow / orange female in 'Alba' forms, xanthopterin, sepiapterin, and erythropterin are reduced, but the colourless leucopterin is increased. The concentration of sepiapterin is determined by a single gene locus and a multiple-allele system (Watt & Bowden, 1966).

Because of their role in colour signal production in the male of *C. eurytheme* and other sulphurs, pteridines, in combination with multilayer thin-film nanostructures and broadband scattering features, may themselves provide important information for females in the mating process (Rutowski *et al*., 2005). It is supposed that in contrast to orange males, white 'Alba' males should always present a selective disadvantage, especially in the choice of a partner. The maintenance of the 'Alba' type over evolutionary time scales could be explained by the selection for tight linkage between the 'Alba' locus and the sex determiner locus. Unfortunately, 'Alba' males in *C. croceus* occur only in extremely rare cases, so clarifying the genetic basis would be difficult.

In addition to the importance of wing colouration for mating behaviour, the wing pigments, the morphological wing structures, and the position of the wings to sunlight are of great importance for thermoregulation. Kingsolver (1987) investigated the role of pteridine pigments and melanin patterns for thermoregulation in pierids. In the subfamily Coliadinae, the ventral melanin patterns of the hind wing bases are decisive for thermoregulation; in Pierinae, it is the entire dorsal wing surface. The whitish colouration of the Pierinae caused by leucopterin and isoxanthopterin is also found in the 'Alba' forms of *Colias*. For thermoregulation, the Coliadinae close all their wings ('lateral basking position'), whereas the Pierinae leave their wings open with different opening angles to regulate the intensity of reflection ('reflectance basking position'; Kingsolver, 1985). This phenomenon in Pierinae is phylogenetically derived (Kingsolver, 1987). However, the reflectance basking position only makes sense with pigments of bright wings. Nonetheless, the 'Alba' forms in *Colias* seem just as effective in thermoregulation as the orange forms via the method of 'lateral basking' (Watt, 1973).

It is inspiring to find such an extremely rare butterfly individual in one of the smaller islands of the Atlantic Ocean with mostly semi-arid conditions.

Fig. 1 – Orange female (left) and 'Alba' female (right) of *Colias croceus*, collected on Porto Santo Island (Madeira Archipelago), east of Capela de São Pedro, 31 m, N 33° 02′ 49.5″ W 16° 21′ 32.5″, 21 March 2017.

Fig. 2 – Orange male (left) and 'Alba' male (right) of *Colias croceus*, collected on Porto Santo Island (Madeira Archipelago), east of Capela de São Pedro, 31 m, N 33° 02′ 49.5″ W 16° 21′ 32.5″, 21 March 2017, and north Serra de Dentro, 70 m, 33° 05′ 14.6″ – 16° 18′ 33.5″, 21 March 2017.

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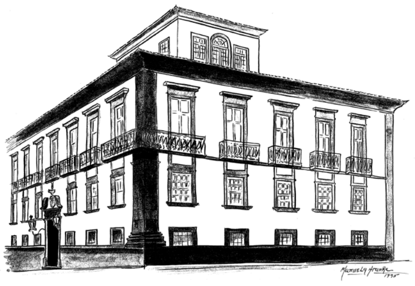

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New record of an alien grass, *Ehrharta erecta* Lam. (Poaceae), for the Island of Madeira (Portugal)

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With 4 figures

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ABSTRACT: The panic veldt grass, *Ehrharta erecta* Lam., is recorded herein for the first time from the island of Madeira. Several populations of this alien grass have been found in several localities of the island, indicating its naturalization. Once present in a region, *E. erecta* is able to spread relatively quickly because its seeds can be easily dispersed by wind or water over short distances, or by birds and human activities over longer distances. Its vector of introduction to the island of Madeira is unknown, since the plant is apparently not used as an ornamental species, in agriculture, or in the local ethnobotany. Given the locations where it was found, this neophyte was most likely, introduced accidentally as a soil contaminant in the pots of ornamental, exotic plants or mixed with forage plant seeds. In Madeira, *E. erecta* may become invasive in low altitude, natural habitats or in the surrounding areas, blocking natural processes of secondary ecological succession. Its potential for invasiveness must be monitored.

Keywords: *Ehrharta*, Poaceae, new record, naturalization, Madeira.

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RESUMO: A gramínea, *Ehrharta erecta* Lam., é assinalada pela primeira vez para a ilha da Madeira. Foram encontradas várias populações desta erva alóctone em várias localidades do território insular indicando a sua naturalização. Uma vez presente numa região, *E. erecta* tem a capacidade de expandir a sua área de distribuição com relativa facilidade e rapidez, pois as suas sementes são dispersas a curtas distâncias pelo vento ou pela água e a longas distâncias pelas aves. Tanto quanto é do nosso conhecimento sobre esta espécie alienígena, desconhece-se o seu vetor de introdução na ilha da Madeira, visto que a planta, aparentemente, não é utilizada como espécie ornamental, agrícola, ou na etnobotânica local. De acordo com os locais onde foi encontrado, este neófito foi, provavelmente, introduzido acidentalmente através do solo de vasos de plantas ornamentais exóticas ou misturado com sementes de plantas forrageiras. Na Madeira, *E. erecta* pode tornar-se invasora nos habitats de baixa altitude ou nas áreas circundantes, bloqueando processos naturais de sucessão ecológica secundária. O seu potencial de invasão deverá ser monitorizado.

Palavras-chave: *Ehrharta*, Poaceae, novo registo, naturalização, Madeira.

INTRODUCTION

The archipelago of Madeira, located in the Northeast Atlantic, is situated approximately 900 km southwest of Europe (Lisbon, Portugal) and 630 km northwest of the West African coast (Casablanca, Morocco). It comprises the islands of Madeira, Porto Santo and the Desertas and together with the Selvagens, Canary Islands, Azores and Cape Verde archipelagos, makes up the biogeographical zone of Macaronesia. The Mediterranean climate of Madeira is deeply influenced by the northeast trade wind system, with weather conditions varying considerably between the south and north coasts and according to altitude. The island of Madeira, as many other oceanic islands, is very vulnerable to new introductions of alien species not only because of its climate, but also due to the high volume of traffic in people and goods that the island experiences annually.

According to Jardim & Sequeira (2008), the flora of Madeira comprises 1,226 vascular plant *taxa* (species and subspecies), 29 (2.4%) of which are 'possible introduced' and 401 (33.3%) 'introduced'.

With this new record, the grass family (Poaceae) on the archipelago of Madeira totals 139 native and introduced *taxa* (Cope, 1994; Jardim & Sequeira, 2008; Cabral *et al*., 2020).

Ehrharta Thunb., is a grass genus with approximately 35 species (Calvo & Moreira-Muñoz, 2018), native on Eastern and Southern Africa, including the southern part of Central Africa, as well as Yemen and Saudi Arabia, New Guinea and several islands of the Indo-Pacific and Tasmania (Powo, 2019).

In the Euro-Mediterranean area four species from this genus are recorded: *Ehrharta calycina* Sm. (Spain and Tunisia), *Ehrharta delicatula* Stapf (Italy), *Ehrharta erecta* Lam. (France, Israel, Israel-Jordan, Italy, Morocco, Netherlands, Portugal, Sardinia and Spain) and *Ehrharta longiflora* Sm., Canary Islands (Gran Canaria), Spain and Madeira Island (Valdés & Scholz, 2009; Cabral *et al*., 2020).

In mainland Portugal, Menezes de Sequeira *et al*. (2011) recognize one *taxon* belonging to this genus, *E. calycina* Sm., occurring as introduced. Garcia (1946), however, first recorded *E. erecta* Lam. (panic veldt grass) as subspontaneous, based on specimens collected around Coimbra area, in mainland Portugal, and Almeida (2002) states that this species continues to be found frequently in this locality. Verloove & Gullón (2012) also found *E. erecta* Lam., growing in the Algarve (Cacela Velha), Southern Portugal, in 2010.

Regarding the Macaronesian archipelagos, only *E. longiflora* Sm. is reported; it was recorded for the first time from Gran Canaria (Canary Islands, Spain) as an escapee from cultivation (Kunkel, 1978) and, more recently, from the Island of Madeira, as a probable escapee from forage cultivation, since it was found fully naturalized near an agricultural field in the municipality of Calheta (on the south west of the island) (Cabral *et al*., 2020). *Ehrharta erecta* is not reported to Macaronesia (Palhinha, 1966; Sánchez-Pinto *et al*., 2005; Schäfer, 2005; Acebes Ginovés *et al*., 2010; Silva *et al*., 2010).

Until now, *E. erecta* Lam. has not been reported on the island of Madeira (Lowe, 1831, 1856, 1864; Menezes, 1894, 1899, 1905, 1914, 1926a, 1926b, 1927; Hansen, 1968, 1969, 1970, 1971, 1973, 1974, 1978, 1987, 1992; Eriksson *et al*., 1979; Hansen & Sunding, 1993; Cope, 1994; Vieira, 2002; Quintal, 2007; Jardim & Sequeira, 2008; Cabral *et al*., 2020) and is recorded here for the first time from this island.

MATERIAL AND METHODS

The specimens of *Ehrharta erecta* Lam., reported herein, were identified according to Kellog (2015) and (Smith Jr., 2012a, b), and are deposited in the Herbarium of the Funchal Natural History Museum (MADM). Coordinates were obtained using Garmin GPSMAP 78 series GPS and plotted on Google Earth (Fig. 1).

Fig. 1 – Geographical locations where *Ehrharta erecta* Lam. was collected on the island of Madeira.

Material examined

Ehrharta erecta Lam., Encycl. 2: 347 (1786)
(Fig. 2 – A, B, C).

Portugal, Madeira:

On an abandoned vineyard, Serrado, Porto da Cruz, Machico, 10.VII.2019, João Ferreira *leg.*, 32º 45′ 32.0′′ N, 16º 49′ 44.6′′ W, 174 m *a.s.l.* (MADM 7106);

On a garden in front of the main entrance of Pestana Promenade Hotel, São Martinho, Funchal, 12.VII.2019, João Ferreira *leg.*, 32º 38′ 15.2′′ N, 16º 56′ 12.3′′ W, 25 m *a.s.l.* (MADM 7020);

On the west sidewalk at the International Airport of Madeira, Santa Cruz, 17.VII.2019, Juan Silva *leg.*, 339 m *a.s.l.* (MADM 7095);

On an abandoned agriculture terrace, Maroços, Machico, 31.VII.2019, João Ferreira & Juan Silva *leg.*, 32º 44′ 09.9′′ N, 16º 47′ 47.6′′ W, 165 m *a.s.l.* (MADM 7125);

On an abandoned garden, near Snack Bar "As Pedras", Ponta Delgada, São Vicente, 31.VII.2019, João Ferreira *leg.*, 32º 49′ 08.0′′ N, 16º 59′ 26.7′′ W, 210 m *a.s.l.* (MADM 7111).

General description

The description of *E. erecta* found in Madeira, follows that given in GrassBase – The Online World Grass Flora as detailed below (Clayton *et al.*, 2002 onwards):

Habit: perennial; caespitose. Culms decumbent; 40-100 cm long; 4-6 -noded; rooting from lower nodes. Leaf-sheath auricles falcate. Ligule an eciliate membrane; 2-7 mm long; entire, or lacerate; truncate, or obtuse. Leaf-blades 4-20 cm long; 2-10(-15) mm wide. Inflorescences: an opened, or contracted panicle; linear, or elliptic; equilateral, or nodding; 6-20 cm long. Primary panicle branches appressed, or ascending; 1-3 -nate; simple. Panicle branches stiff; smooth, or scaberulous. Spikelets solitary. Fertile spikelets pedicelled. Pedicels filiform; 2-10 mm long. Spikelets: comprising 2 basal sterile florets; 1 fertile floret; without rhachilla extension. Spikelets oblong; laterally compressed; (3-)4-5.75(-6.8) mm long; breaking up at maturity; disarticulating below each fertile floret. Floret callus glabrous, or pubescent. Glumes: persistent; similar; shorter than spikelet; thinner than fertile lemma. Lower glume ovate; 3-3.6 mm long; 0.8 length of upper glume; membranous; 1-keeled; 3(-5) -veined. Lower glume apex obtuse, or acute. Upper glume ovate; 2.5-4.5 mm long; 0.8 length of adjacent fertile lemma; membranous; without keels; 5 -veined. Upper glume apex emarginate, or acute. Florets: Basal sterile florets similar; barren; without significant palea; attached to and deciduous with the fertile. Lemma of lower sterile floret elliptic; 5.4 mm long; coriaceous; 1-keeled; 5 -veined; smooth, or rugose; rough above; glabrous, or hispidulous; obtuse. Lemma of upper sterile floret elliptic; basally auriculate; 6.5 mm long; 1.2 length of lower sterile floret; coriaceous; smooth, or rugose above; obtuse, or acute. Fertile lemma ovate; 2.5-5.5 mm long; coriaceous; keeled; 5 -veined. Lemma midvein scaberulous. Lemma lateral veins with cross-veins. Lemma apex obtuse. Palea 2 -veined. Palea keels approximate; scaberulous. Flowers: Lodicules 2; obovate; membranous; 2-toothed; obtuse. Anthers 6; 1.5-2 mm long. Flowering time: I-VIII (Almeida, 2002). Chromosomes: 2n=24 (Smith Jr., 2012b).

Key for the *Ehrharta* species occurring in the Island of Madeira (adapted from Smith Jr., 2012a):

1. Sterile lemma awns 0; stamens 6 ----------------- ***E. erecta***
Sterile lemma awns 2–20 mm; stamens 3 -- ***E. longiflora***

Fig. 2 – *Ehrharta erecta* Lam.: **A)** general aspect; **B)** close-up of the inflorescence; **C)** florets.

CONCLUSION

In its native range, *E. erecta* Lam. is found in a great variety of habitats, including shady forest, open areas, disturbed areas and sand dunes (Ray *et al.*, 2018). Once present in a region, *E. erecta* is able to spread quickly, because seeds can be easily dispersed for short distances by wind or water and for longer distance by birds (Ogle, 1988) and by human activity (*e.g.*, gardening equipment or clothing). The seeds of panic veldt grass may also be carried as contaminants in potted plants (Gluesenkamp, 2004) and may be introduced to new regions via imported garden soil and in birdseed (McIntyre & Ladiges, 1985; Ogle, 1988). *E. erecta* has the potential to swamp lower growing native species in invaded habitats, as well as increasing the fire risk and adding to the accumulation of organic matter. Rapid spread within a region is possible because formation of seed occurs rapidly, within several weeks of flowering and its germination rates are high, recorded as 99% within 11 months in Australia (McIntyre & Ladiges, 1985) where this grass species is widely naturalized. According to Ogle (1988), the capacity of panic veldt grass to flower and to produce copious seeds, if soil moisture conditions are adequate, together with the capacity to reproduce vegetatively by rooting at the nodes of its decumbent flower stems, means that its control is a continuous task. Portuguese legislation puts *E. erecta*, together with *E. calycina* Sm., on the list of species introduced in mainland Portugal, considered as invasive according to the Decree Law No. 565/1999, Series I-A of 1999-12-21 that regulates the introduction into nature of non-indigenous species of flora and fauna.

Plant invasions represent the most serious threats in those regions of the world that were under the influence of human colonization (di Castri, 1989). The climatic conditions of the island of Madeira and its high volume of trade in goods and people, make the island highly vulnerable to new introductions. Since 1500 AD, several neophyte were recorded to Madeira and has been well documented over the last one hundred and fifty years by several authors (Lowe, 1831, 1856, 1864; Menezes, 1894, 1899, 1905, 1914, 1926a, 1926b, 1927; Hansen, 1968, 1969, 1970, 1971, 1973, 1974, 1978, 1987, 1992) and compiled by Vieira (2002). *Ehrharta erecta* is now added to the list of many other introduced *taxa* found on the island of Madeira in the last 12 years (Gonçalves Silva *et al.*, 2008, 2009; Ferreira *et al.*, 2011; Benedito & Menezes de Sequeira, 2014; Pupo-Correia & Menezes de Sequeira, 2014; Gonçalves Silva & Paz Rúben, 2016; Gonçalves Silva & Ferreira, 2019; Cabral *et al.*, 2020; Ferreira *et al.*, 2020) and whose occurrence may negatively affect the structure, functioning and recovery of natural habitats (Stinca & Mei, 2019).

The vector of introduction of *Ehrharta erecta* to the island of Madeira is unknown. As far as we know, the plant is not used as an ornamental plant, in agriculture and has no known ethnobotanical uses. This neophyte was, most likely, accidentally introduced as a soil contaminant in pots of ornamental plants or mixed with seeds of forage plants since we observed it in both gardens and in "abandoned" agricultural terraces.

As stated previously, *E. erecta* has the capability to sustain self-replacing populations without direct human intervention, either by recruitment from seeds or by ramets (tillers, tubers, bulbs, fragments, etc.). Considering the high number of individuals found in the field work carried out in recent years, that will produce, in short time, a high number of fertile offspring at considerable distances from the parent plants, we consider it as another invasive, naturalized species on the Island of Madeira.

By analysing the locations where this species was found or observed *in loco* by the authors on the island of Madeira, it is safe to say that panic veldt grass, like its counterpart *E. longifolia*, occupies an altitudinal range that covers, according to Capelo *et al*. (2004), the Madeiran Mediterranean secondary grass communities (namely, *Dactylo hylodes-Hyparrhenietum sinaicae*, *Cenchro ciliaris-Hyparrhenietum sinaicae* and *Bromo-Oryzopsion miliacei*). Unless carefully monitored and managed, *E. erecta* Lam. is likely to become invasive in those areas and in the neighbourhood. This in turn could affect, for example, the endemic fish-stunning spurge communities (*Euphorbietum piscatoriae*), leading to the blocking of natural processes of ecological succession (Cabral *et al*., 2020).

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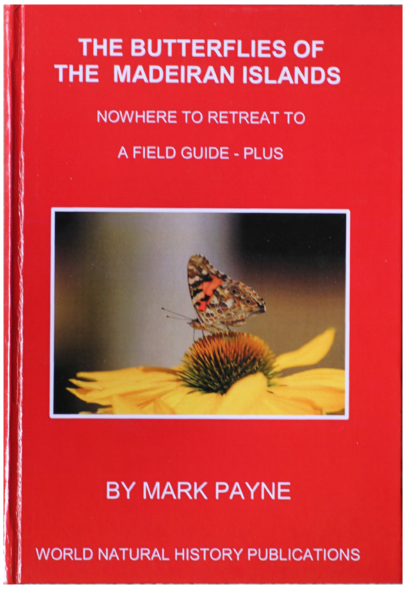
BOOK REVIEW



The Butterflies of the Madeiran Islands
Nowhere to Retreat to
A Field Guide – Plus
By Mark Payne, 322 pp., hard back 162 x 240 mm. [No. ISBN number provided]. World Natural History Publications, The Lake District, UK, 2019. Price: £ 60.00.

A book seller's website gives a description of this book indicating that it is an in-depth scientific examination of the butterflies of the Madeiran Archipelago; however, errors throughout the book as described in this review, clearly demonstrate that this is not so. The errors start right at the beginning with the same misspelling of Alfred Russell (sic) Wallace repeated from two of his earlier books (Payne, 2019a, 2019b) on page 2 and the opening line of the Preface (p. 4) incorrectly stating that this is the only book on Madeiran Rhopalocera (see alternative book suggestions at the end of this review). Pages 3, 4 and 5 are reprinted almost word for word and with the same errors as in the author's previous book on the Azores butterflies, for example acknowledging the assistance of Matt Rowlands (sic). Had the author read the reviews of his previous books by the Reviewer (2020a) and Tennent (2020a, 2020b) perhaps he could have made appropriate corrections.

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Chapter 1 consists of a reproduction of part of *The butterflies and moths of Teneriffe* (Holt White, 1894) and quotes from de Worms (1964); the Reviewer considers that the first is irrelevant to a supposed field guide to the butterflies of the Madeiran Islands and the second uses butterfly names that are now outdated. The author uses the word 'endemic' incorrectly; he lists *Vanessa vulcania* Godart, 1819 as an endemic of Madeira, at the same time stating (correctly) that it is present in the Cabo Verde and Canary Archipelagos *i.e.* strictly it is an endemic of Macaronesia, not just Madeira (Wakeham-Dawson *et al*., 2002). Many of the researchers referred to in this section are absent from the bibliography, thus the reader cannot verify what has been reported by the author properly. For example, page 51 consists of a list of butterflies recorded, including some which the Reviewer calls into question as per later comments.

In addition, pictures in this book are most often from the internet or not correctly acknowledged, or at times not directly relevant; for the 26 pictures of Madeiran landscapes plus four of those of Porto Santo, none have a location and all are from the internet. Rose-Marie Haccour is again absent from the acknowledgements, despite providing the same seven photographs of *Vanessa vulcania* as published twice in his previous books (Payne, 2019a, 2019b). Also see the Reviewer's later comments regarding photographs used for *L. phlaeas phlaeoides*.

Chapter 3 consists of detailed accounts of species apparently recorded from the Madeiran Archipelago, but often with misleading or unscientific rationale or references that cannot be verified. It begins with *Cacyreus marshalli* (Butler, 1898) (sic), showing its presence on a map covering the whole of Madeira is based on one sighting of a single larva, which failed to produce a butterfly, on a cultivated *Pelargonium* sp. (Aguiar & Karsholt, 2006: 92) and thus is misrepresentative of the butterfly's apparent current absence from Madeira. Details of the presence of *Lampides boeticus* (Linnaeus, 1767) on Madeira and Porto Santo follow, with information from previous researchers; however, it follows with a repetition from the author's book concerning the Azores (Payne, 2019b: 101-104) of the work done in India by Palem et al. (sic) (2015) (the author frequently omits proper use of italics in the references) which is not referenced and was not on *L. boeticus* at all (Tennent, 2020a), so should not be included here. The works of Stefanascu, Jubany and Obregon (sic) (2018), Cano (1984), Obregon (sic), de Haro, Jordano & Fernandez Haeger (sic) (2012) are quoted and cited at length in the text, but none of these references appear in the bibliography, so it is impossible for the reader to consult them. The information about the larvae eating cocoons of the parasite *Cotesia specularis* (Szepligeti, 1896) is irrelevant to those found in the Madeiran Islands, since that nearest colony of this parasite is in Germany (https://fauna-eu.org/cdm_dataportal/taxon/99298630-3612-4232-973c-6ae72e3bad12) (accessed 26.04.2020).

The first record of *Leptotes pirithous* (Linnaeus, 1767) in Madeira was made by Hall & Russell (2001), not 2000 as suggested from the author's reference, nor 2002 as suggested in the author's incorrect quotation from Kratochwil et al. (sic) (2018) (misspelt in the author's references as Kratochwill).

The selected examples above perfectly demonstrate the inability of the author to either give correct dates or accurately transcribe other researchers' articles, of which this book mostly consists.

Since this book includes 'Field Guide' in its title, it would have been appropriate to have some comparative photographs or line drawings of *Lycaena phlaeas* (Linnaeus, 1761) and *L. phlaeas phlaeoides* (Staudinger, 1901) for the reader to compare the differing wing pattern in the endemic Madeiran subspecies, instead of six photographs of European specimens, since photographs of the endemic subspecies can readily be found on the internet. The author has included two and a half pages on the early stages of *L. phlaeas* in Europe (citing ten articles, none of which are referenced in the bibliography), which are irrelevant to the Madeiran butterfly.

The presence of *Phengaris arion* (Linnaeus, 1758) in Madeira reported by Dawson (1992) is doubted by Wakeham-Dawson *et al.* (2004) in favour of a misidentification of *L. boeticus*. The author however accepts and reports on the existence of the species on Madeira but provides no valid indication as to how it reached Madeira; the author reports correctly that it emerges from a nest of *Myrmica sabuleti* Meinert, 1861, but this ant species has never been recorded from Madeira or The Azores; it has single dubious records from the Canary Islands and Morocco, and other records requiring verification from Portugal (https://www.antwiki.org/wiki/Myrmica_sabuleti#Distribution_based_on_AntMaps) (accessed 26 April 2020). In the Reviewer's opinion, as per the references cited above, the presence of this species in Madeira indicated by the author's map of the "known distribution of *Phengaris arion*" is unscientific and misleading. The Reviewer also considers the two pages and distribution map provided concerning *Danaus chrysippus* (Linnaeus, 1758) are unscientific and inappropriate; this species has also never been recorded reliably from the Madeiran Archipelago.

Danaus plexippus (Linnaeus, 1758) is discussed in detail but the text includes five pages on its presence on the Azores Archipelago, which the Reviewer considers to be irrelevant to a book concerning butterflies of the Madeiran Islands. Of the eight pages on *Vanessa atalanta* (Linnaeus, 1758), about 90% of the text refers to the species in Europe and includes numerous references, none of which are in the bibliography. The section on *Vanessa cardui* (Linnaeus, 1758) has half a page on its presence in Madeira compared to four and a half pages about its presence in Europe, again with references not included in the bibliography. The presence of *Vanessa virginiensis* (Drury, 1773) was, according to the author, 'recorded' by Rebel (1917), Higgins & Riley (1973) and Oehmig (1977) but this is not so; all merely 'reported' the supposed and unsupported record by Godman (1870), who was probably referring to a different island (Aguiar & Karsholt, 2006: 91). No further observations of this butterfly on Madeira have been recorded or reported yet the book includes five pages of text concerning this species. There are 21 text pages concerning *Vanessa vulcania* (Godart, 1819) (sic) again with many references which are not in the bibliography. The photographs of this species provided by Rose-Maria Haccour have no location of origin provided, and for the third time this lady has no acknowledgement for providing them (see Payne, 2019a, 2019b). The colour plates depicting *V. cardui*, *V. atalanta*, *D. chrysippus* and *D. plexippus* amongst others, none with any data or from the locations under discussion, have been used for the third time (see Payne, 2019a, 2019b).

Moving on to the Satyrinae, the discussion on *Hipparchia maderensis* (Bethune-Baker, 1891) is extraordinarily long (27 pages), including much on other Hipparchia species, which the Reviewer considers to be irrelevant to a book on butterflies of the Madeiran Islands. As has been stated previously, what is needed for a 'Field Guide' is a description of its distinguishing characteristics, compared with say *H. semele* (Linnaeus, 1758), together with some suitable photographs or line drawings, not a text monograph. To this could be added some detail of habitat and places where the species is likely to be seen. The reference to the Russell et al. (sic) (2004) in the bibliography is incomplete as pp. 197-208 should have been included. The author continues with *Hipparchia statilinus* (Hufnagel, 1766) (sic), reporting incorrectly again that it was recorded by Higgins & Riley (1983). Chapter 6 consists of 40 pages dedicated to *Pararge xiphia* (Fabricius, 1775) and *P. aegeria* (Linnaeus, 1758), and the Reviewer questions whether it is all relevant to such a book? The Reviewer again considers that some annotated drawings showing the differences between the two species is needed.

The 'sighting' of *Papilio machaon* Linnaeus, 1758 in Madeira is not yet substantiated with sufficient evidence to be conclusive; in the Reviewer's opinion more evidence is necessary. The author has included *Colias hyale* (Linnaeus, 1758) as being recorded from Madeira as he did in his book on the butterflies of the Azores (Payne, 2019b); Russell (2020b) presented the facts, including that there was no specimen caught on the island of São Miguel, as suggested by Payne (2019b: 153). The research required to sort out the question of the presence or absence of this species in Madeira has been conducted by the Reviewer and the results published separately (Russell, 2020c). The Reviewer is satisfied that the record should be discounted, as has been done by the majority of entomologists; the nearest verified population of *C. hyale* is currently in north-western Spain, some 2,000 km distant.

The section on *Gonepteryx maderensis* (Felder, 1862) (sic) consists mainly of reproductions of the articles of Aguiar, Wakeham-Dawson & Jesus (2009) and Merit & Merit (2010), of which the latter has not been referenced. Since Matt Rowlings had not been to Madeira and thus was unable to supply the photographs for this species (Plate 39), all are from the internet with no data, in spite of the fact that all the data were available. At this stage the Reviewer makes reference to three molecular cladograms: figure 2 (p. 149 – not 140 as indicated in the author's table of contents, p. 9), figure 8 (p. 202) and figure 10 (p. 245) published against the express wishes of Dr. M. Wiemers. They have been incorrectly attributed by the author to 'Wiemers, 2016', which is a single page abstract of a presentation made at the Island Biology conference 2016, on the butterflies of the Canary Islands and Madeira (see reference) and does not include any of these cladograms. It should also be noted that some parts of the cladograms have been published by different authors in various publications at different times but the author gives no indication of this and by publishing these figures is considered to have infringed the copyrights of a number of different authors. According to personal communications between the Reviewer and Martin Wiemers on 23 April 2020, Wiemers on 17 January 2020 specifically requested the author, by email, not to publish these figures and the author responded on the same day saying they would be removed from the book, which was not due to be printed until 17 February; however, it has been suggested to the Reviewer that copies of the book were already available at the end of January.

The presence of *Pieris brassicae* (Linnaeus, 1758) was reported by Whiting (1901), who also reported *P. napi* (Linnaeus, 1758) for Madeira; the Reviewer, in common with all other researchers on Madeiran butterflies, doubts the records of both.

The section on *Pieris wollastoni* (Butler, 1886), has recently been confirmed as a full species (Wiemers *et al*., 2018), which was accepted by the author but is not in the bibliography (the Reviewer has referenced it). In this section, as has been found to be usual in the author's books reviewed by the Reviewer, there is a great deal of unnecessary and rude comments about other researchers' works. On page 283 there are a number of different molecular cladograms (Fig. 11, p. 283), incorrectly referenced to Wiemers, 2016, and one of these again blatantly infringes copyright. Another of the cladograms in this figure is of the *P. cheiranthi* / *wollastoni* complex, but the author has adulterated this cladogram by crossing out the letters '*oid*' from *Pieris brassicoides* Guérin-Méneville, 1849, found in Ethiopia. This makes the resulting '*brassices*' a nonsense and demonstrates the unprofessional attitude the author takes to other researchers' work. The Reviewer has received permission to refer to these cladograms from Martin Wiemers (*pers. comm*. 23 April 2020).

The Reviewer also has some comments on the photographs in plate 42, all purporting to be of the taxon *wollastoni*. As has been noted (but not by the author) in descriptions of this species, the distinguishing features of this taxon are threefold: firstly in the female on the upperside, but not the underside, there are two black streaks (sometimes weak) from the discal black spot to the apical black mark; secondly in this sex there are often two or three faint black points between the two large black spots; thirdly the hindwing undersides in both sexes are extensively dusted with black scales (Manley & Allcard, 1970); there are some excellent pictures in their book of specimens taken by Allcard. It is noted that the bottom left hand photograph in the author's plate 42 is of two of Allcard's females, which demonstrate these characters exceptionally well. When the Allcard collection was dispersed, all his specimens of *wollastoni* passed through the hands of the Reviewer and thus he is very familiar with the variation of this taxon. The photograph of the Madeiran postage stamp has correctly got the forewing black streaks and the general appearance of *wollastoni*. The upper two photographs (one from the Aistleitner collection, origin illegible, and the other from the Ziegler collection, *ex larva* Ribeira Brava) again demonstrate the diagnostic features. The central right-hand side photograph, however, is again from the internet and is not of *wollastoni*, but of *P. brassicae*; as far as the Reviewer is aware there are no photographs of the imagine of *wollastoni* in *vivo* and the underside is not heavily dusted with the characteristic black scales. As a point of note the originator of this photograph has allowed for it to be copied, but only with due acknowledgement, which the author has ignored. The central left photograph is reproduced from Holt White (1894: Plate I, Fig. 1), taken from the internet, but this figure is of *P. cheiranthe*, despite the original author's legend and it does not show the definitive characters of *P. wollastoni*. These latter two photographs are a perfect demonstration of the dangers of taking other people's illustrations from the internet without having sufficient knowledge of Lepidoptera to identify the species which they represent; this has been demonstrated in the author's books on many occasions previously (Russell, 2020a, 2020c; Tennent, 2020a, 2020b). What would have been useful for a book of this nature would have been some accurate line drawings, as provided by Owen & Smith (1993: 218), which clearly shows the differences between *P. cheiranthi* and *P. wollastoni*.

It is noted that the Bibliography has been reduced from 55 pages in the authors previous books (Payne, 2019a, 2019b) to just over five pages; this probably accounts for the fact that it contains very few of the references quoted in the text. The many omissions make it impossible for the reader to investigate the claims made by the author. This section is also marred by the lack of accented letters and incorrect journal abbreviations.

In the opinion of the Reviewer, this book is hopelessly unscientific and it is not recommended to anyone interested in obtaining a field guide to the butterflies of Madeira, since it bears no resemblance at all to a ‘field guide’. If readers are in need of a proper field guide to Madeiran butterflies, then the 2001 one by Wakeham-Dawson, Salmon & Franquinho Aguiar, referenced below, is excellent.

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