

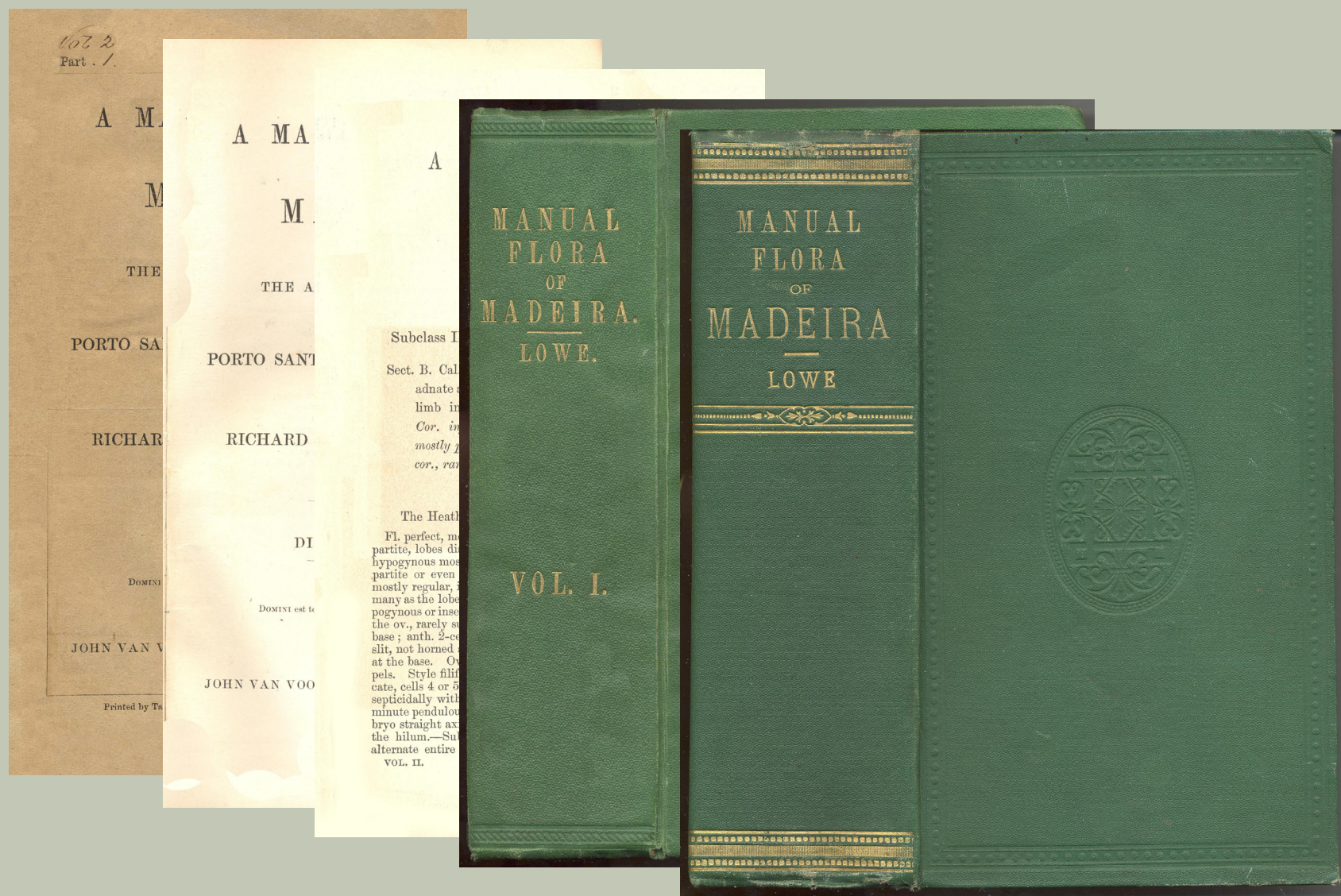


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Editor:

MANUEL JOSÉ BISCOITO
Departamento de Ciência e de Recursos Naturais da CMF
E-mail: manuel.biscoito@cm-funchal.pt

Co-editores // Associated editors:

ANTÓNIO FRANQUINHO AGUIAR
Laboratório Agrícola da Madeira
E-mail: antonioaguiar.sra@gov-madeira.pt
RICARDO ARAÚJO
Museu de História Natural do Funchal
E-mail: ricardo.araujo@cm-funchal.pt
FRANCESCA ZINO
E-mail: f@zino.co.uk

Secretária editorial // Editorial board secretary:

IVELICE GONÇALVES
Departamento de Ciência e de Recursos Naturais da CMF
E-mail: ivelice.goncalves@cm-funchal.pt

Composição // Desktop publishing:

Ivelice Gonçalves
Museu de História Natural do Funchal

Arranjo gráfico // Layout:

Virgílio Gomes

Ivelice Gonçalves

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Manuela Aranha
Imagem // Image:
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Secretariado e correspondência // Address:

Museu de História Natural do Funchal
Rua da Mouraria, 31
9004-546 Funchal
Madeira – Portugal
Telefone // Phone: (+351) 291 229761
Fax: (+351) 291 225180
E-mail: mmf.pubs@cm-funchal.pt

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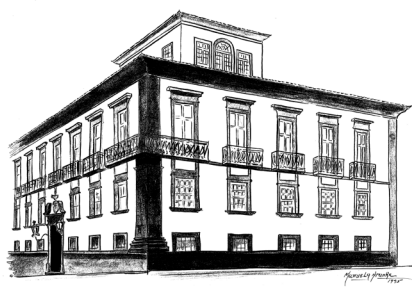
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Museu de História Natural do Funchal

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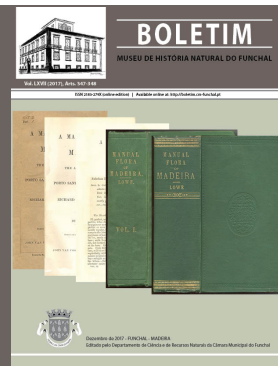
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The publication dates of the parts-issue of Richard Thomas Lowe's *A Manual Flora of Madeira (1857-1872)*, with a publishing history

By R. B. WILLIAMS¹

With 5 figures and 2 tables

¹ Norfolk House, Western Road, Tring, Hertfordshire HP23 4BN, United Kingdom. E-mail: ray.coxitec@tesco.net

ABSTRACT: *A Manual Flora of Madeira and the Adjacent Islands of Porto Santo and the Desertas* by Richard Thomas Lowe, was published in demy duodecimo parts between 1857 and 1872 by John Van Voorst. It is a classic of careful botanical description, still relevant to modern research on the flora of the Madeiran Archipelago. Because of the inclusion in the work of new taxa and other valuable historical information, it is crucial to date as precisely as possible each of the six parts (publication of which was cut short by Lowe's death in April 1874), and to record the exact contents of each part; the work is not illustrated. The publication dates of the five parts comprising volume I were no later than: 16 November 1857 (pages [i-ii], [i]-xii, [1]-106); 31 January 1862 (pages [107]-262); 30 December 1863 (pages [263]-[378]); 4 February 1868 (pages [379]-522); 31 December 1868 (pages 523-618). Only the first part of volume II was published, no later than 31 March 1872 (pages [1]-[116]). The consolidated volume I was published in December 1868; it was subsequently combined with part I of volume II, and reissued in 1874 or later. Descriptions of the publisher's known cloth-case designs are presented. Comments on the general reception by fellow-botanists and the publishing history of the whole work are also provided. By 1884, Van Voorst had apparently sold the remaining stock to Bernard Quaritch, the London bookseller.

Keywords: Bernard Quaritch, bibliography, John Van Voorst, *Manual Flora of Madeira*, parts-issue, publication dates, publishing history, Richard Thomas Lowe.

RESUMO: A obra *A Manual Flora of Madeira and the Adjacent Islands of Porto Santo and the Desertas*, da autoria de Richard Thomas Lowe, foi publicada em demi-duodécimo partes entre 1857 e 1872, por John Van Voorst. Trata-se de um clássico com descrições botânicas cuidadas, ainda relevante para a investigação botânica atual do arquipélago da Madeira. Dado que contém novos taxa e valiosa informação histórica, torna-se crucial datar, o mais precisamente possível, cada uma das seis partes. A obra não é ilustrada. As datas de publicação das cinco partes que compreendem o volume I não são posteriores a: 16 de novembro de 1857 (páginas [i-ii], [i]-xii, [1]-106); 31 de janeiro de 1862 (páginas [107]-262); 30 de dezembro de 1863 (páginas [263]-[378]); 4 de fevereiro de 1868 (páginas [379]-522); 31 de dezembro de 1868 (páginas 523-618). Somente a primeira parte do volume II foi publicada não depois de 31 de março de 1872 (páginas [1]-[116]). O volume I consolidado foi publicado em dezembro de 1868 e foi subsequentemente combinado com a parte I do volume II, tendo sido lançado em 1874 ou depois. No presente trabalho é descrito o design das capas feitas pelo editor e são relatados comentários críticos acerca da obra, publicados por colegas botânicos da época. É também descrita a história da publicação de toda a obra. Em 1884, Van Voorst terá aparentemente vendido o restante stock da obra ao livreiro londrino Bernard Quaritch.

Palavras-chave: Bernard Quaritch, bibliografia, John Van Voorst, *Manual Flora of Madeira*, datas de publicação, história de publicação, Richard Thomas Lowe.

INTRODUCTION

The first book to describe fully all of the native vascular plants of the Madeiran and Salvage Islands was published in relatively recent times, *The Flora of Madeira* by PRESS *et al.* (1994): “It is 70 years since any comprehensive work devoted to the flora of the Madeiran islands has been produced” (page vii). Earlier contributions to Madeiran botany are widely scattered. Of these early works, the best-known is the incomplete flora by LOWE (1868 [1857-1872]), published by John Van Voorst of Paternoster Row, London; it is one of the classic unfinished works listed by CORNS & SPARKE (1915). Nevertheless, NORMAN (1887) alluded to it as the most complete flora up to 1887.

“From time to time, before the year 1857, fragmentary and intermittent notices of the flora of the island of Madeira, and lists of some of its plants, were published both in England and in Germany, but no serious attempt to produce a complete and systematic flora was made till that year, when the first number of *A Flora of Madeira and the Adjacent Islands of Porto Santo and the Desertas*, by the Rev. Richard Thomas Lowe, M. A., was brought out by Van Voorst of London.”

The correct title of Lowe’s work is *A Manual Flora of Madeira and the Adjacent Islands of Porto Santo and the Desertas*, referred to hereinafter simply as *The Flora*. Like many other Victorian natural history works it was published in separate parts, and ascertaining their precise publication dates has hitherto proved to be difficult

and uncertain. However, since *The Flora* contains newly published taxa and nomenclatural acts, as well as valuable natural history notes with important historical and biographical information (for instance, WILLIAMS, 2016), it is essential to analyse and date the page-gatherings of the letterpress more precisely than has hitherto been done. That is, therefore, the objective of the present paper.

PREVIOUSLY RECORDED DATES FOR THE PARTS OF THE FLORA

Whilst it may appear somewhat hypercritical and presumptuous to draw attention to the errors and omissions of dating committed by previous authors and in bibliographical catalogues, it is nevertheless necessary, in the light of the present research, to prevent their perpetuation. Thus, all the earlier references to the six individual parts that could be found, providing either incorrect or, at best, imprecise publication dates accurate only to a year, are given here.

For instance, PRITZEL (1872: 197), since his bibliography of botanical literature was finished in 1871, could include only the completed first volume, issued in 1868 (part I of volume II did not appear until 1872). Similarly, JACKSON (1881: 353) recorded only the date range for the parts of volume I, simply as 18[57]-68, and did not mention a publication date for part I of volume II. WOODWARD (1910) recorded, without evidence, just the year-dates of the parts in the

British Museum (Natural History) catalogue. MENEZES (1914) uncritically cited the date of the finally consolidated volume I plus volume II (part I) as 1868 (as it is incorrectly shown thus on the title-page). Even the renowned Victorian book seller Bernard QUARITCH (1881: 160) erroneously dated that consolidated volume, "*all that ever will be published*", as 1868-1871. The assertion (ANONYMOUS, 1874a) that two parts of volume II were published is wrong.

In the twentieth century, HANSEN (1968, 1969a, 1970) published year-dates for the five parts comprising the completed volume I. Overlapping these papers, he had also cited a range of year-dates from 1857 to 1872 for the work up to the final part published (HANSEN, 1969b, 1973), but did not identify the component letterpress except for the first part of volume II (HANSEN, 1971). Later, without providing any evidence, he again published year-dates of the six individual parts (HANSEN, 1974); and repeated, again without evidence, the same information in a bibliography (HANSEN, 1976). It seems most likely, since his last bibliography included an early obituary of Lowe providing the year-dates of each part (ANONYMOUS, 1874b), that Hansen's original source was that obituary.

Surprisingly, STAFLEU (1967) did not include *The Flora* in his first edition of *Taxonomic Literature* but in the second edition (STAFLEU & COWAN, 1981: 178, item 5049) brief references to ANONYMOUS (1874b) and HANSEN (1974) were made, simply restating the years given by HANSEN (1974, 1976). PRESS *et al.* (1994) unfortunately cited the dates of the consolidated parts as 1859-1872, apparently a *lapsus calami*.

PUBLICATION DATES OF THE PARTS

In the present study, the latest possible publication date, as near to the actual day as possible, has been established for each part. This dating is based upon a combination of sources, including any printed or manuscript dates given by the publisher on original wrappers; annotations by recipients of presentation copies; the accession dates of legal-deposit (copyright) copies received by the then British Museum (now the British Library); the publisher's own dated advertisements; and the earliest reviews found in periodicals. When only a month and year are ascertainable for the publication of a part, the last day of that month must be accepted as the earliest reliable date for the purpose of nomenclatural precedence. These procedures have established much more precise publication dates for the parts, including an earlier year than hitherto known for part III.

Original parts of *The Flora* are extremely rare; there appears to be no complete set available for examination of loose parts in wrappers, as individually issued. It has been necessary, therefore to assemble information from a number of bound-up examples, which are summarized in Table 1; none of them includes all of the complete wrappers. In any case, since the wrappers themselves provide scant printed information on dates of issue, the most valuable sources proved to be the bound British Museum legal-deposit volumes (recognized by their blue receipt-date stamps) now held by the British Library (BL); and Professor Charles Cardale Babington's (CCB) personal bound set of the parts now held in the Plant Sciences Library of the University of Cambridge. Babington's copy is inscribed "Prof. Babington. With kind regards, R. T. Lowe" and, although lacking wrappers, the letterpress of each part is annotated, with varying precision, with its date of receipt from Lowe. Disappointingly, no corroboration of any receipt-dates appears in Babington's published correspondence (see BABINGTON, 1897). The dates of receipt of the parts collected in these volumes, together with additional relevant information gleaned from other sources, are provided below. The combined information is summarized in Table 2, where the latest possible publication date of each part is indicated in bold type.

Part I of volume I

Wrapper date MDCCCLVII (printed); BL legal-deposit accession date, 16 November 1857; no CCB receipt date; earliest review, 5 December 1857 (ANONYMOUS, 1857a); earliest Van Voorst advertisement, December 1857; date according to HANSEN (1976), 1857.

Part II of volume I

Wrapper date MDCCCLXII (originally printed MDCCCLVII, but amended in manuscript), January (manuscript); BL legal-deposit accession date, 30 December 1863; CCB receipt, January 1862; earliest review, 1 March 1862 (ANONYMOUS, 1862a); no Van Voorst advertisements found; date according to HANSEN (1976), 1862.

Part III of volume I

Wrapper date 1864 (originally printed MDCCCLVII, but amended in manuscript); BL legal-deposit accession date, 30 December 1863; CCB receipt, January 1864; earliest review, 13 February 1864 (ANONYMOUS, 1864a); no Van Voorst advertisements found; date according to HANSEN (1976), 1864.

Table 1 – *A Manual Flora of Madeira*: examples examined during the present study.

Library	Shelf-mark	Contents	Provenance	Binding	Wrappers included
R. B. Williams	A	Volume 1 only	Unknown	Publisher's cloth	None
R. B. Williams	B	Volume 1 only	Unknown	Full calf	None
R. B. Williams	C	Volume 1 + 2 (part 1)	R. Milne-Redhead	Publisher's cloth	None
R. B. Williams	D	Volume 1 + 2 (part 1)	T. G. Tutin	Publisher's cloth	None
R. B. Williams	E	Volume 1 only	Herbier Boissier	Publisher's cloth	None
R. B. Williams	F	Volume 2 (part 1) only	Herbier Boissier	Library buckram	Volume 2 (part 1), front
Cambridge University, Cory Library	-	Volume 1 + 2 (part 1)	Unknown	Publisher's cloth	None
Cambridge University, Herbarium Archive	CGE 13.14	Volume 2 (part 1) only	Capt ⁿ Norman R.N.	Original wrappers	Volume 2 (part 1)
Cambridge University, Plant Sciences Library	HF 21	Volume 1 + 2 (part 1)	Presented by Lowe to Charles C. Babington	Library binding	None
Cambridge University Library	MD.30.35	Volume 1 only	Unknown	Library binding	Volume 1 (part 1)
Cambridge University Library	MD.30.36	Volume 2 (part 1) only	Unknown	Original wrappers	Volume 2 (part 1)
Royal Botanic Gardens, Kew	1	Volume 1 + 2 (part 1)	Charles Baron Clarke	Library binding	Volume 2 (part 1), front only
Royal Botanic Gardens, Kew	2	Volume 1 + 2 (part 1)	Unknown	Library binding	None
British Library	7032.c.31	Volume 1 only	Legal deposit (copyright)	Library cloth	Volume 1 (parts 1-5)
British Library	7032.c.31	Volume 2 (part 1) only	Legal deposit (copyright)	Library cloth	Volume 2 (part 1)
Instituto Botânico, University of Coimbra, Portugal	B-88/537	Volume 1 (part 1) only	Jardim Botânico (online digitized)	Original wrappers	Volume 1 (part 1)
Bayerische Staatsbibliothek, Germany	Phyt. 411i	Volume 1 (part 1) only	Biblioteca Regia Monacensis (online digitized)	Original wrappers	Volume 1 (part 1)

Table 2 – *A Manual Flora of Madeira*: latest possible publication date of each part deduced from the earliest dates compiled from secondary sources.

Date sources	Vol I, part I	Vol I, part II	Vol I, part III	Vol I, part IV	Vol I, part V	Vol II, part I
Wrappers	1857	January 1862	1864	1868	Not dated	Not dated
British Museum legal-deposit receipts	16 November 1857	30 December 1863	30 December 1863	4 July 1868	Not recorded	11 May 1872
Babington's receipts of Lowe's presentations	Not known	January 1862	January 1864	4 February 1868	December 1868	March 1872
Earliest reviews in periodicals	5 December 1857	1 March 1862	13 February 1864	6 February 1869	6 February 1869	1 April 1872
Earliest Van Voorst advertisements	December 1857	None found	None found	May 1868	None found	None found
Hansen (1976)	1857	1862	1864	1868	1868	1872
Latest possible publication date	16 November 1857	31 January 1862	30 December 1863	4 February 1868	31 December 1868	31 March 1872

Part IV of volume I

Wrapper date 1868 (manuscript), no printed date; BL legal-deposit accession date, 4 July 1868; CCB receipt, 4 February 1868; earliest review, 6 February 1869 (ANONYMOUS, 1869a); earliest Van Voorst advertisement, May 1868; date according to HANSEN (1976), 1868.

Part V of volume I

Wrapper, no printed or manuscript date; BL legal-deposit accession date not recorded; CCB receipt, December 1868; earliest review, 6 February 1869 (ANONYMOUS, 1869a); no Van Voorst advertisements found; date according to HANSEN (1976), 1868. In the section of *Addenda et corrigenda*, LOWE (1868 [1857-1868]) referred (page 605) to "the present moment (Nov. 1868)", which is consistent with Babington receiving his copy in December of that year.

Part I of volume II

Wrapper, no printed or manuscript date; BL legal-deposit accession date, 11 May 1872; CCB receipt, March 1872; earliest review, 1 April 1872 (ANONYMOUS, 1872); no Van Voorst advertisements found; date according to HANSEN (1976), 1872.

PUBLICATION DATES OF THE CONSOLIDATED VOLUMES

Ideal copies (*sensu* GASKELL, 1974) of *The Flora* issued by the publisher as a single volume exist in two forms: the first (before Lowe's death) comprises parts I-V forming volume I; and the second (after Lowe's death) comprises volume I bound with the first and only part issued of volume II.

A common practice of Van Voorst (along with other Victorian publishers) was to issue the consolidated volume of a book that had been published in parts simultaneously with the appearance of the final separate part (see for instance, WILLIAMS, 2014, 2017). Regarding *The Flora*, volume I was therefore probably issued contemporaneously with publication of part V during December 1868 (see above), and its title-page indeed bears the year-date 1868. A review published between January and March 1869, of volume I only, noted that Lowe "a publié depuis, de 1857 à 1864, le *Manual Flora of Madeira*, qui à cette époque s'arrêtait au Araliacées [end of part III] et qui maintenant est plus avancé" (ANONYMOUS, 1869b). This suggests that the consolidated volume I was indeed issued simultaneously with part V and, if so, must have been published no later

than 31 December 1868 (see Table 2). There is therefore no apparent reason to dispute the date of 1868 on its title-page.

The final consolidation of volume I with the first part of volume II was a direct result of the death of Lowe, when Van Voorst was faced with the certainty that the monograph would never be finished, at least by its original author. The volume includes the same printing of the title-page as of volume I alone, and so the date of 1868 is, in this case, certainly spurious. The issuing of this volume was probably fairly soon after Lowe died in April 1874, but I have been unable to trace any contemporary advertisements for it.

Nevertheless, any uncertainty existing about the precise publication date of either of the consolidated volumes of *The Flora* is not crucial when considering nomenclatural precedence of new taxa. Dating of the parts adequately serves that purpose.

STUDY METHODS FOR ANALYTICAL BIBLIOGRAPHY

For the present bibliographical descriptions, the conventions published by GASKELL (1974) for collational formulae and for calculations of the sheet-sizes of paper were adopted. Sizes and nomenclature of Victorian English printing-paper are provided by GOULD (1876). Comparisons of type-settings in the parts and the consolidated volumes were made by MCKERROW'S (1927) transect method. Descriptions of book-cloths conform to the system of KRUPP (2008). Pagination of wrappers follows the convention proposed by WILLIAMS (2005) thus: w[1] = recto (outer page) of front wrapper; w[2] = verso (inner page) of front wrapper; w[3] = recto (inner page) of back wrapper; w[4] = verso (outer page) of back wrapper.

The copies of the parts-issue and the book-issues of *The Flora* examined for this study are listed in Table 1. They include two digitized examples of part I of volume I, both with exactly the same contents. One is held by the University of Coimbra, Portugal, and appears online at URL "http://bibdigital.bot.uc.pt/obras/UCFCTBt-B-88-5-37/UCFCTBt-B-88-5-37_item2/UCFCTBt-B-88-5-37_PDF/UCFCTBt-B-88-5-37_PDF_24-C-R0120/UCFCTBt-B-88-5-37_0000_capa-capat24-C-R0120.pdf" (accessed 22 January 2017). This copy is especially instructive for collation because it shows the actual appearance of the wrappers and leaves, revealing the original sewing of the gatherings. The other example is less useful for analytical bibliography, because its images

are cropped. It is held by the Bayerische Staatsbibliothek, Germany (accessed 22 January 2017), URL "http://reader.digitale-sammlungen.de/de/fs1/object/display/bsb10302419_00126.html". The only other separate parts traced were two copies of part I (volume II) as separately issued in wrappers, and another two in library bindings (Table 1).

Except for the few individual parts in wrappers, some bound volumes of the letterpress with at least some of the wrappers included were available for examination. The British Library (previously the British Museum legal-deposit (copyright) repository for the United Kingdom), possesses a complete copy of volume I in a library binding with the wrappers sewn at the end, so the contents are not in their exact original order. Some other libraries also possess all of the letterpress bound with very few of the wrappers (Table 1). From these sources, I have been able to reconstruct the exact contents of each part, now dated as closely as possible to its actual day of publication.

COMPOSITIONS OF THE PARTS

The composition of each dated part is crucial for the correct application of publication dates to new taxa or historical facts. The copies personally examined for the present study include all the original parts-issues, most of which are now bound up, that could be found in the United Kingdom, supported by the two previously mentioned digitized copies of part I of volume I (see Table 1). The wrappers and the letterpress are now described. *The Flora* is not illustrated.

The wrappers

Only the British Library (BL) copy includes all of the front wrappers. They are of a dark buff colour, except those of part III, which are more yellowish. All bear various manuscript amendments and insertions; the prices in particular are always in manuscript. Such use of surplus wrappers of earlier parts, altered in manuscript, was not an unusual practice of Van Voorst. Examples are, for instance, *A History of British Molluscs and their Shells* (see FISHER & TOMLIN, 1935), and *A History of British Starfishes* (see WILLIAMS, 2014); other examples are also known (personal observations). The printing on page w[1] of the wrapper of part I is the most complete, excess stocks of which were modified for subsequent parts; pages w[2] and w[3] were blank in all parts examined of which front and back wrappers were intact. Their printing, which is corroborated

by the wrappers bound into various other library-copies, is described below (see also Fig. 1).

Volume I, part I. Most of the printing on the front wrapper (page w[1]) is within a single-ruled frame (151 × 87 mm), and is shown below in quasi-facsimile:

| A MANUAL FLORA | OF | MADEIRA | AND | THE
ADJACENT ISLANDS | OF | PORTO SANTO AND THE
DEZERTAS. | BY | RICHARD THOMAS LOWE, M.A. | [30 mm
rule] | DOMINI est terra, et plenitudo ejus.–Psal. xxiv. 1. |
LONDON : | JOHN VAN VOORST, 1 PATERNOSTER ROW. |
MDCCCLVII. |

In addition, immediately above the frame is printed: to the left, "Part I. Thalamifloræ." and to the right "Price". Immediately after "Price" appears "3/6" in manuscript (this was a short way of writing 3s. 6d. or three shillings and sixpence). Immediately below the frame appears "Printed by Taylor and Francis, Red Lion Court, Fleet Street". Pages w[2] and w[3] are blank, and page w[4] lists 14 titles of "Books on Botany, Published by Mr. Van Voorst."

Volume I, part II. The printing of page w[1] is identical to that of part I, but there are further manuscript amendments. Thus, the "I" in "Part I." is overwritten with a "2". The price remains at 3/6 in manuscript. "Thalamifloræ." is amended thus: "~~Thalamifloræ.~~ Calycifloræ". In the printed date "MDCCCLVII", the "V" is altered in manuscript to "X", and "January" is added, also in manuscript. Pages w[2] and w[3] are blank, and page w[4] lists 14 titles of "Books on Botany, Published by Mr. Van Voorst.", the same as in part I.

Volume I, part III. The printing of page w[1] is identical to that of part I, with further manuscript amendments similar to those in part II. The "I" in "Part I." is overwritten with "3". The price remains at 3/6 in manuscript. However, "Thalamifloræ." remains as in the original printing. The date "MDCCCLVII" is corrected thus: "MDCCCLVII. 1864.". Pages w[2] and w[3] are blank, and page w[4] lists 14 titles of "Books on Botany, Published by Mr. Van Voorst.", the same as in part I.

Volume I, part IV. The printing of page w[1] is almost identical to that of part I, with various manuscript amendments. For the part number, only "Part" is printed, and in the following space is inserted "4". The price remains at 3/6 in manuscript. In the title, the "Z" previously printed in "DEZERTAS" is replaced with a printed "S" (a wrong fount). There is no printed date, but "1868" is given in manuscript. The back wrapper is missing.

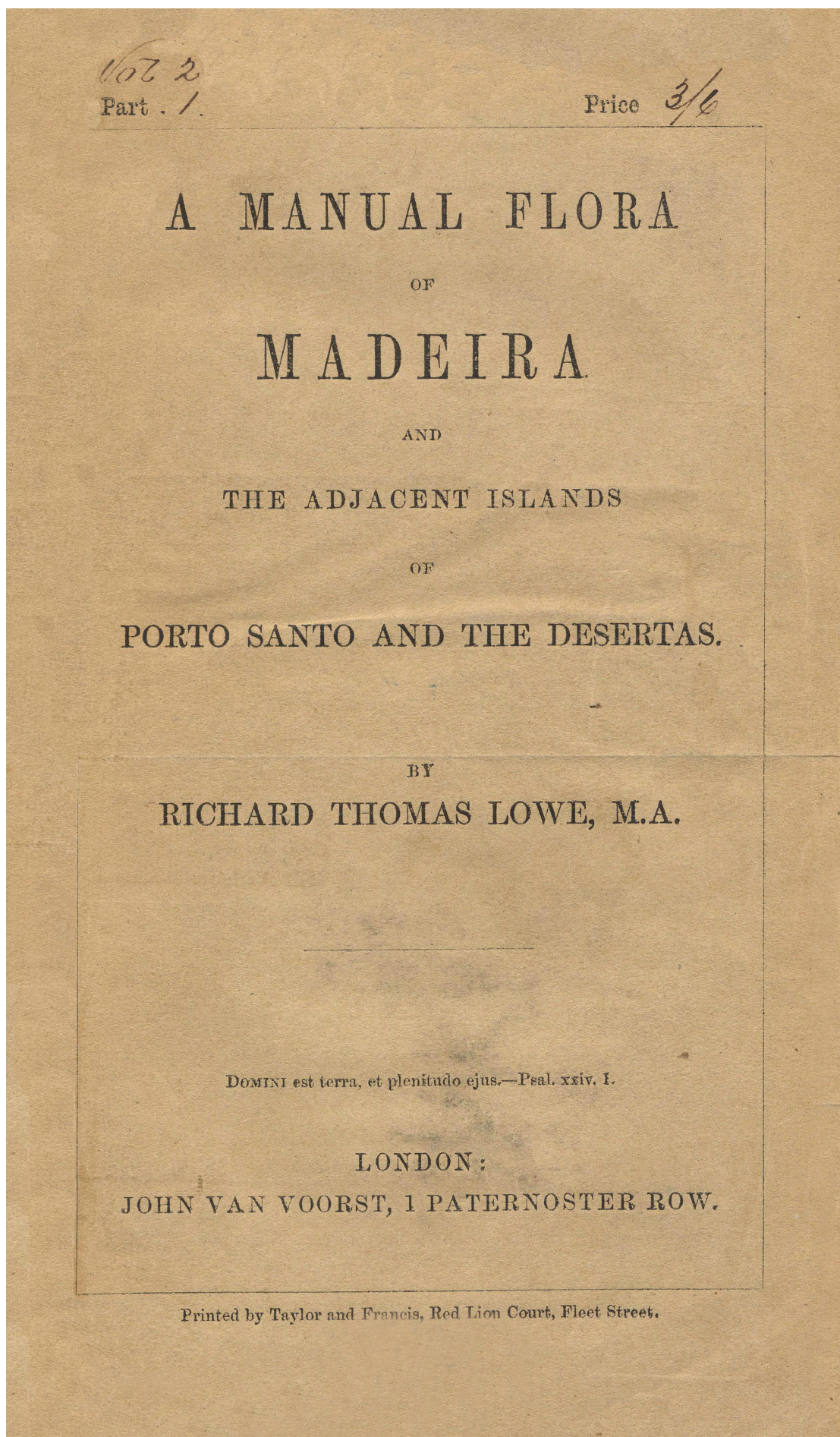


Fig. 1 – *A Manual Flora of Madeira*: front wrapper (page w[1]) of part I of volume II.

Volume I, part V. The printing of page w[1] is identical to that of part IV, with similar manuscript amendments. For the part number, only “Part” is printed, and in the following space is inserted “5 (Completing Vol 1)”. The price remains at 3/6 in manuscript. The printed correction of “DEZERTAS” to “DESERTAS” is repeated. There is neither a printed, nor a manuscript, date. The back wrapper is missing.

Volume II, part I. The printing of page w[1] is identical to that of part V, with similar manuscript amendments. “Part” is printed, and in the following space is inserted “1”, with “Vol 2” above it. The price remains at 3/6 in manuscript. The printed correction of “DEZERTAS” to “DESERTAS” is also repeated. There is neither a printed, nor a manuscript, date (see Fig. 1). Pages w[2], w[3] and w[4] are blank.

The letterpress

For each demy duodecimo part, the collational formula, pagination and number of leaves are given, with further notes on supplementary matter printed on the wrappers or inserted advertisements. Numbered pages are paginated at the top, outer corner (except for the second page ii at top centre). Pages shown in square brackets here are not numbered.

Volume I, part I: π1 a⁶ B–E¹² F⁴ (F4+χ1); pages [i-ii] [i] ii-xii [1] 2–106; 60 leaves. [Leaf π1 bears a temporary title-page for this part only, with the printer’s imprint on the verso. The first three leaves of gathering a⁶ are signed (the third misleadingly) a, a2, a5. Gatherings of twelve leaves are signed on the first, second and fifth; but F⁴ is signed only on the first two.]

The temporary title-page reads (in quasi-facsimile):

| A MANUAL FLORA | OF | MADEIRA | AND | THE
ADJACENT ISLANDS | OF | PORTO SANTO AND THE
DEZERTAS. | BY | RICHARD THOMAS LOWE, M.A. | [30
mm rule] | PART I. THALAMIFLORÆ. | RANUNCULACEÆ—
PITTOSPORACEÆ. | [31 mm rule] | DOMINI est terra et
plenitudo ejus.—Psal. xxiv. 1. | LONDON : | JOHN VAN
VOORST, 1 PATERNOSTER ROW. | MDCCCLVII. |

There is an advertisement leaf tipped-in at the end, printed on the recto “NATHANIEL HASLOPE MASON F.L.S. 3, Red Lion Square, London, W. C.”, offering natural history collections from Madeira, Porto Santo and the Dezertas of dried and living plants, wood samples, land shells and marine invertebrates (the verso is blank).

Volume I, part II: G–M¹² N⁶; pages [107] 108–262; 78

leaves. [Gatherings of twelve leaves are signed on the first, second and fifth; N⁶ is signed on the first three.]

Volume I, part III: O–R¹² S⁶ T⁴; pages [263] 264–377 [378]; 58 leaves. [Gatherings of twelve leaves are signed on the first, second and fifth; S⁶ is signed on the first three; T⁴ is signed on the first two. Page [378] is blank.]

Volume I, part IV: U–2A¹² 2B–2C⁶; pages [379] 380–522; 72 leaves. [Gatherings of twelve leaves are signed on the first, second and fifth; gatherings of six leaves are signed on the first three.]

Volume I, part V: 2D–2F¹² 2G–2H⁶; pages 523–582 [583] 584–613 [614–615] 616–618; 48 leaves. [Gatherings of twelve leaves are signed on the first, second and fifth; gatherings of six leaves are signed on the first three.]

Volume II, part I: B–E¹² F¹⁰; pages [1] 2–113 [114–116]; 58 leaves. [All gatherings are signed on the first, second and fifth leaves.]

The number of leaves in the five parts of volume I is 316, and in the first part of volume II is 58, totalling 374. Leaf size of original parts, all edges uncut: 188 × 112 mm (shape ratio 1.68). Following GASKELL’S (1974) method for estimating the sheet size of gatherings signed in twelves, the full size is estimated to be 564 × 448 mm, corresponding to a Victorian demy sheet of 22½ × 17¾ inches as given by GOULD (1876), which confirms the format as duodecimo.

COMPOSITION OF THE CONSOLIDATED VOLUMES

The present description is based upon detailed examination of copies of the book-issues included in Table 1. They comprise three copies of volume I only, and three copies of volume I cased with part I of volume II. The title-page of the consolidated five parts of volume I (LOWE, 1868 [1857–1868]), completed during Lowe’s lifetime, is dated 1868 (see Fig. 2). After Lowe’s death, before which he had published part I of volume II, Van Voorst issued a final consolidation of all six parts with a title-page identical to that of volume I alone (see Fig. 2). It reads (in quasi-facsimile):

| A MANUAL FLORA | OF | MADEIRA | AND | THE
ADJACENT ISLANDS | OF | PORTO SANTO AND THE
DESERTAS. | BY | RICHARD THOMAS LOWE, M.A. | [27 mm
rule] | VOL. I. | DICHLAMIDEÆ. | [27 mm rule] | DOMINI est
terra et plenitudo ejus.—Psal. xxiv. 1. | LONDON : | JOHN
VAN VOORST, 1 PATERNOSTER ROW. | MDCCCLXVIII. |

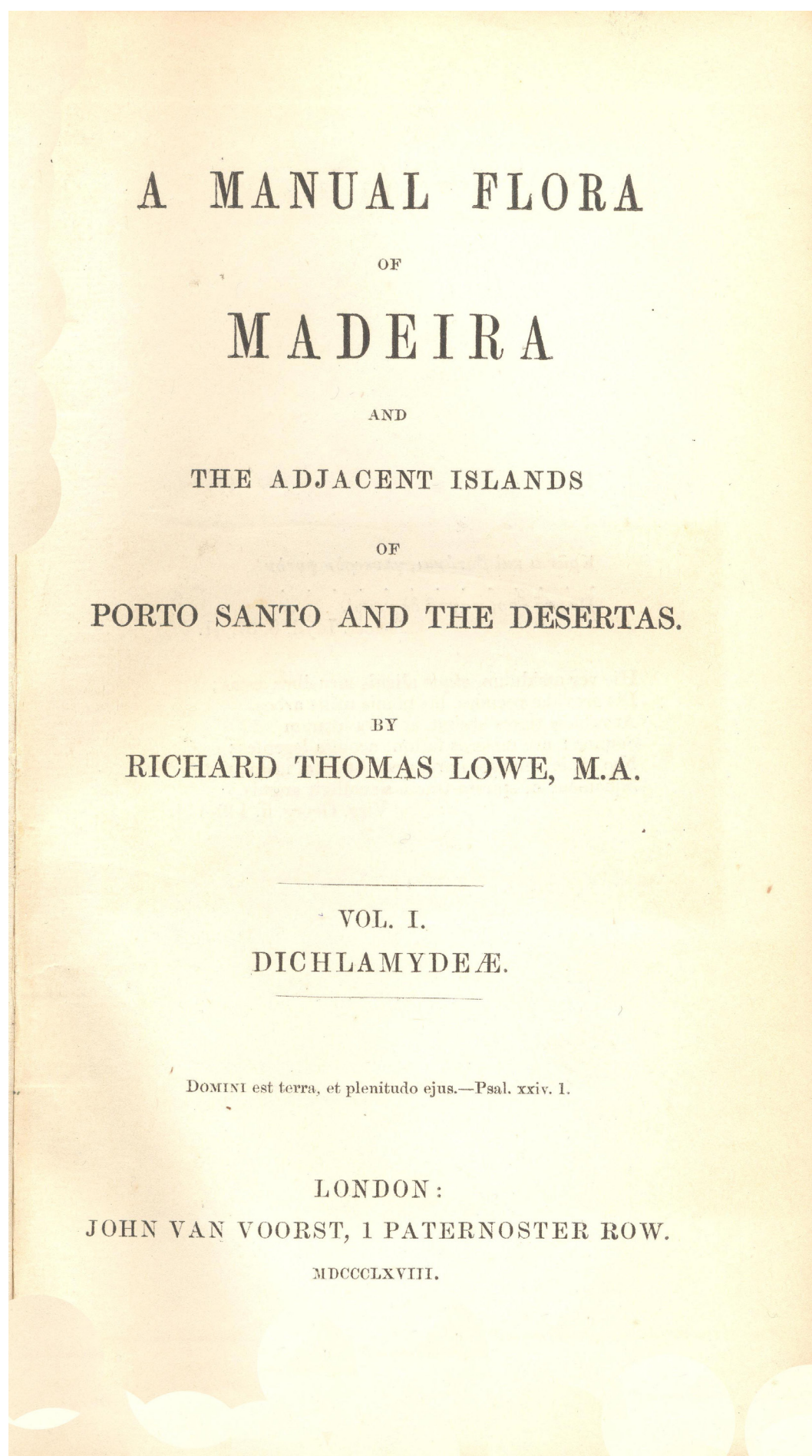


Fig. 2 – *A Manual Flora of Madeira*: title-page common to the consolidated volume I, and to volume I plus part I of volume II.

Volume I alone

The collational formula for publisher's ideal copy (*sensu* GASKELL, 1974: 315) of volume I (LOWE, 1868 [1857-1868]) cased alone is:

Demy duodecimo: $\pi 1$ ($-\pi 1$) $2\pi^2$ a^6 B-E¹² F⁴ (F4+ $\chi 1$) G-M¹² N⁶ O-R¹² S⁶ T⁴ U-2A¹² 2B-2C⁶ 2D-2F¹² 2G-2H⁶ [\$1, 2, 5 signed ($-2\pi 1$, $2\pi 2$, $a5$; $a3$ signed ' $a5$ '; \$3 for gatherings of six; \$2 for gatherings of four)]. The temporary title-page of part I (leaf $\pi 1$) is excised. Total 317 leaves. Leaf size, all edges uncut: 188 × 112 mm (shape ratio 1.68).

The composition is:

iv + xii + 618 pages; [i-iv] [i] ii-xii [1] 2-106 [107] 108-262 [263] 264-377 [378-379] 380-582 [583] 584-613 [614-615] 616-618. Paginated at top, outer corners of pages, except for the second page iii, which is at top centre. Pages shown in square brackets here are not numbered.

All the copies of volume I alone in publisher's cloth that were examined had the same content, which is as follows:

[i] title-page; [ii] two-line Greek and six-line Latin quotations; [iii] dedication to T. V. Wollaston; [iv] blank; [i]-ii notice; iii-xii explanations and abbreviations; [1] Class I. Exogens or Dicotyledons; 2-106 Subclass I. Thalamifloræ; [107]-262 Subclass II. Calycifloræ; [263]-377 Subclass II (continued); [378] blank; [379]-582 Subclass III. Corollifloræ; [583]-613 *Addenda et corrigenda* for parts I-V; [614] blank; [615]-618 Index of families and genera in vol. I; 618 printer's imprint.

Volume I bound with volume II (part I)

The collational formula for publisher's ideal copy of volume I cased with volume II, part I (LOWE, 1868 [1857-1872]) is:

Demy duodecimo: $\pi 1$ ($-\pi 1$) $2\pi^2$ a^6 B-E¹² F⁴ (F4+ $\chi 1$) G-M¹² N⁶ O-R¹² S⁶ T⁴ U-2A¹² 2B-2C⁶ 2D-2F¹² 2G-2H⁶ B-E¹² F¹⁰ [\$1, 2, 5 signed ($-2\pi 1$, $2\pi 2$, $a5$; $a3$ signed ' $a5$ '; \$3 for gatherings of six; \$2 for gatherings of four)]. The temporary title-page of part I (leaf $\pi 1$) is excised. There is no separate title-page for volume II; below the dropped-head title on page [1] (see Fig. 3), the text simply continues from page 582 of volume I as in the separate part I of volume II. Total 375 leaves. Leaf size, all edges uncut: 188 × 112 mm (shape ratio 1.68). All the copies in publisher's cloth that were examined had the same content, except that Van Voorst's integral advertisement leaf at the end may have been excised; in such cases, the final gathering is F¹⁰ (-F10).

The composition is:

iv + xii + 618 + 116 pages; [i-iv] [i] ii-xii [1] 2-106 [107] 108-262 [263] 264-377 [378-379] 380-582 [583] 584-613 [614-615] 616-618 [1] 2-113 [114-116]. Paginated at top, outer corners of pages, except for second page iii, which is at top centre. Pages shown in square brackets here are not numbered.

The contents are as follows:

[i] title-page; [ii] two-line Greek and six-line Latin quotations; [iii] dedication to T. V. Wollaston; [iv] blank; [i]-ii notice; iii-xii explanations and abbreviations; [1] Class I. Exogens or Dicotyledons; 2-106 Subclass I. Thalamifloræ; [107]-262 Subclass II. Calycifloræ; [263]-377 Subclass II (continued); [378] blank; [379]-582 Subclass III. Corollifloræ; [583]-613 *Addenda et corrigenda* for parts I-V; [614] blank; [615]-618 Index of families and genera in vol. I; 618 printer's imprint; [1]-113 Subclass III. Corollifloræ (continued); [114] blank; [115-116] 'Books on Botany, Published by Mr. Van Voorst' and 'Students' Class-Books'.

The Van Voorst advertisement leaf (F10) lists 30 titles on recto and verso; a longer list than that on page w[4] of the wrappers of parts I-III.

TYPOGRAPHY

The Flora was printed by the highly-respected firm of Taylor and Francis, Red Lion Court, Fleet Street, London (see BROWN, 1982); they specialized in printing and publishing scientific literature (and still do), and often produced books for Van Voorst (BROCK & MEADOWS, 1984). The printer's imprint is rather obscure in the consolidated volumes, occurring only at the foot of page 618 of volume I. However, in the parts, it is found on all of the front wrappers and on the verso of the temporary title-page of part I of volume I.

The letterpress of the parts is essentially the same as that of the consolidated volumes (*q.v.*). There are no cancellations of leaves, except for the excision of the temporary title-page of part I (leaf $\pi 1$) from the consolidated volumes. Random transects (McKERRROW, 1927: 183) of pages in the parts-issue are identical to transects of the same pages in the consolidated volume(s); hence, there is only one edition. Imposition was confirmed as a common duodecimo by the occurrence of point-holes at the heads of leaves (see GASKELL, 1974: Figure 55). The work was printed on only one paper size.

Considering the high reputation of Taylor and Francis as printers, the 30 pages of *Addenda et Corrigenda* to parts I-V are, at first sight, quite startling. In fact, a reviewer (ANONYMOUS, 1869a) wryly observed that "The list of

A MANUAL FLORA OF MADEIRA.

VOL. II.—PART I.

Subclass III. COROLLIFLORÆ (*continued*).

Sect. B. Cal.-tube free or rarely and then only partly adnate at the base or downwards to the superior ov. ; limb inferior or very rarely (*Samolus*) half-sup. Cor. *inferior* or at most half-superior. Stam. *mostly perigynous and epipetalous or inserted on the cor., rarely almost or quite free and hypogynous.*

Order LI. ERICACEÆ.

The Heath, Arbutus and Rhododendron Family.

Fl. perfect, mostly regular. Cal. wholly free persistent 4-5-partite, lobes distinct or only subcoherent at the base. Cor. hypogynous mostly gamopetalous and 4-5-fid, sometimes 4-5-partite or even 4-5-petalous, often persistent or marcescent, mostly regular, imbricate in bud. Stam. as many or twice as many as the lobes of cal. or cor., 1-2-seriate, mostly free and hypogynous or inserted with the cor. on an hypogynous disk below the ov., rarely subepipetalous or slightly adnate to cor. at its base ; anth. 2-celled, the cells opening by a terminal pore or slit, not horned at top but appendiculate or caudate sometimes at the base. Ov. superior free of 4-5 and 1-many-ovulate carpels. Style filiform, stigma capitate. Fr. capsular rarely baccate, cells 4 or 5 mostly many-seeded bursting loculicidally and septicidally with 4, 5, or 8-10 valves. Seeds mostly numerous minute pendulous from the central placentæ, scrobiculate ; embryo straight axile in the fleshy albumen ; radicle superior near the hilum.—Subarborescent shr. with mostly evergreen rigid alternate entire sessile rarely opposite or whorled l. without

VOL. II.

B

Fig. 3 – *A Manual Flora of Madeira*: dropped-head title (page [1]) of part I of volume II.

corrigenda is woefully long. Let us hope that in succeeding parts more careful revision will take place, or a separate part will be needed to contain the *corrigenda*". However, examination of these pages ([583]-613) reveals that few, if any, of the corrections are of printing errors; in fact, they comprise mainly Lowe's changes of opinion on taxonomic points, with some quite lengthy additional notes on various species. Although Lowe delayed publication of these amendments to the first five parts for so long, the criticism of the anonymous reviewer was perhaps rather unfair. In fact, it appears from the content of the *Addenda et Corrigenda* section that information received from fellow-botanists such as J. M. Moniz, F. M. Norman and others (see WILLIAMS, 2016), as well as his continued botanizing trips to Madeira and other Macaronesian islands were what stimulated changes of his taxonomic opinions and swelled his original text during a period of eleven years, all published finally in 1868. The number of pages of addenda and corrigenda for each of the five parts (about 14, 12, 2½, 1 and ½ pages, respectively) are directly associated with the time elapsed since their publication, lending some support for this speculation.

PUBLISHER'S CLOTH-CASE DESIGNS

The issues of the consolidated volumes (see above) exhibit differences between the gilt lettering and ornamentation on the spines and between the blind blocking of the boards of the cloth cases. In addition, there is an obvious difference between the thicknesses of the text-blocks. Only two variants of the casing for volume I alone, and two of that for the final consolidation have been discovered. Considering the rarity of this book, that may not be surprising (see later). Part I of volume II was apparently never issued on its own in publisher's cloth, but it may be found separately bound in library cloth. Coloured illustrations of the publisher's cloths are provided here in order to avoid any uncertainties about differences between the designs. Cloth-grains are classified according to KRUPP (2008). The descriptions are given in their likely chronological order of issue. In general, the colours of the cases are green, varying slightly in tone, possibly depending on the degree of exposure to light in the past.

Volume I alone

Case **a** (Fig. 4). Perhaps the primary case (provenance ex-Bibliothèque de l'Herbier Boissier, Geneva). Bright green sand (cloth-grain **Krupp San1**); front board with

blind blocking (border and fancy frame); back board the same as front. The gilt lettering on the spine reads "MANUAL | FLORA | OF | MADEIRA. | [14 mm plain rule] | LOWE.", and lower down, "VOL. I." (with all the full stops spaced widely). Decorative bands in blind at the head and tail (Fig. 4). Boards 195 × 111 mm. All edges uncut. Text-block ca 37 mm thick. The advertisement for the naturalist Mason originally inserted at the end of the separate part I is discarded; no other advertisements present; endpapers brown; no binder's ticket.

Case **b** (cf. Fig. 4). Dark green pebble (cloth-grain **Krupp San5**). Design and size of both boards the same as primary case **a**. Gilt lettering on spine also as for case **a**, except that the lettering is very slightly more spaced out vertically, the plain rule measures 11 mm and each full stop almost touches the preceding letter; blind, decorative bands also the same as for case **a**. Mason's advertisement discarded; no other advertisements present; endpapers cream; no binder's ticket.

Volume I bound with part I of volume II

Case **c** (Fig. 5). Dark green sand (cloth-grain **Krupp San1**); front board with blind blocking (oval central device and border); back board the same as front. The gilt lettering on the spine reads only "MANUAL | FLORA | OF | MADEIRA | [9 mm rule] | LOWE", with a gilt decorative band immediately below. Also decorative bands in gilt at the head and tail (Fig. 5). Boards 196 × 111 mm. All edges uncut. Text-block ca 42 mm thick. Mason's advertisement discarded; last leaf is integral Van Voorst advertisement; endpapers cream; no binder's ticket.

Case **d** (cf. Fig. 5). Dark green sand (cloth-grain **Krupp San1**); front board with blind blocking (oval central device and border); back board has same border but lacks central device. The gilt lettering and decoration on the spine the same as case **c**; also the same decorative bands in gilt at the head and tail (Fig. 5). Boards 195 × 111 mm. All edges uncut. Mason's advertisement discarded; last leaf is integral Van Voorst advertisement; endpapers cream; no binder's ticket.

THE GENERAL RECEPTION OF *THE FLORA* AND ITS PUBLISHING HISTORY

The Rev. Richard Thomas Lowe (1802-1874) was, from 1833 to 1852 the chaplain of the English Church in Madeira, but he had resided there from 1828. His chaplaincy was a

troubled one for many reasons (NASH, 1990), the details of which need not concern us here, but during that period and later, when time allowed, he travelled over the Madeiran Archipelago and wider Macaronesia, collecting plants, fishes and terrestrial invertebrates in particular. Whilst he published a few botanical papers in various journals (LOWE, 1830, 1831, 1834, 1838, 1851, 1856, 1857, 1865, 1866, 1867, 1869), he had long intended to write a comprehensive flora of the Madeiran Archipelago. However, it was not until 1852, when he resigned his chaplaincy in Madeira that he was able to begin work on *The Flora*.

The issuing of the parts of *The Flora* was a protracted affair, interrupted by Lowe's other interests and responsibilities, and was terminated in 1874 by his premature death at sea during yet another voyage to Madeira (NORMAN, 1887; NASH, 1990). Part I is best introduced in his own words from the Notice (page [i]):

"Impeded by graver avocations, and in prospect of being obliged shortly to suspend altogether further progress by the necessity of leaving England for the benefit of health, I have decided on publishing at once the following portion of the Flora of Madeira."

One perceptive reviewer, whilst generally appreciative of Lowe's botanical work, interpreted his introduction rather pessimistically (ANONYMOUS, 1857a), which, unfortunately, probably did little to encourage current and potential subscribers:

"The experience of the author in Madeiran vegetation is greater than any other person's, and a complete work from such a hand would be of very great interest. We fear, however, from what is said in the preface, that there is small hope of the present publication being continued, although what lies before us is called Part I. In the meanwhile we gladly accept the present instalment, which, as far as it goes furnishes the botanist with all that he can require."

Nevertheless, Lowe's otherwise enthusiastic Notice continued (page ii),

"On my return to England it is my purpose, if life be spared, not only to complete the present little publication, but to follow it up, as health and leisure may permit, with a series of similar Manuals on the Ferns and other Cryptogamic plants, the Birds and Fishes, Shells or Mollusks, marine and terrestrial, of the island; such as, in conjunction with the elaborate and admirable works of Mr. Wollaston on

the Insects, may furnish together a tolerably complete Natural History of the Madeiran group."

Although Lowe had already reported some of his work on this grand scheme, in publications issued by Van Voorst on ferns and terrestrial molluscs (LOWE, 1851) and the fishes (LOWE, 1843-1860) of the Madeiran Archipelago, no further development of his plan ever materialized. He wrote nothing about birds. The pessimistic reviewer for the *Gardeners' Chronicle* (ANONYMOUS, 1857a) was clearly quite aware of Lowe's slow rate of publication, and had apparently observed how his initial efforts on ferns, molluscs and fishes had come to naught, long before he reiterated his intentions in 1857.

With regard to *The Flora*, however, Lowe was nevertheless quite sanguine about an ultimate completion (Notice, page ii), opining that:

"In the mean time, no further inconvenience than delay will accrue to the purchasers of the present instalment, in itself complete, of the Phænogamic Flora, by its separate publication. When its sequel is carried through the press, care will be taken to make the paging continuous with that of the part now published, so that the whole may be ultimately bound up in one volume, for which a fresh title-page, with other introductory or prefatory matter, tables, indices, &c., will be supplied."

However, even when volume I was completed in 1868 after a further eleven years, the preliminary matter failed to materialize, except for a title-page and a dedication to his close friend Thomas Vernon Wollaston (1822-1878). In the interim, successive parts met with a mixture of praise for their botanical accuracy and disappointment over their protracted appearance.

The initial pessimism of the *Gardeners' Chronicle* reviewer regarding the likely continuation of the work (ANONYMOUS, 1857a) was balanced somewhat by the review in the *Annals and Magazine of Natural History* (ANONYMOUS, 1857b), thus:

"The author seems to have spared no labour requisite to render his book complete. It is arranged somewhat on the plan of Babington's 'Manual of British Botany,' although usually rather fuller in detail than that work, and containing many more critical remarks than were there requisite ... We have only to add a strong recommendation of this book to the notice of botanists."

Lowe's assiduous attention to descriptive details of each species, with his additional notes on localities and

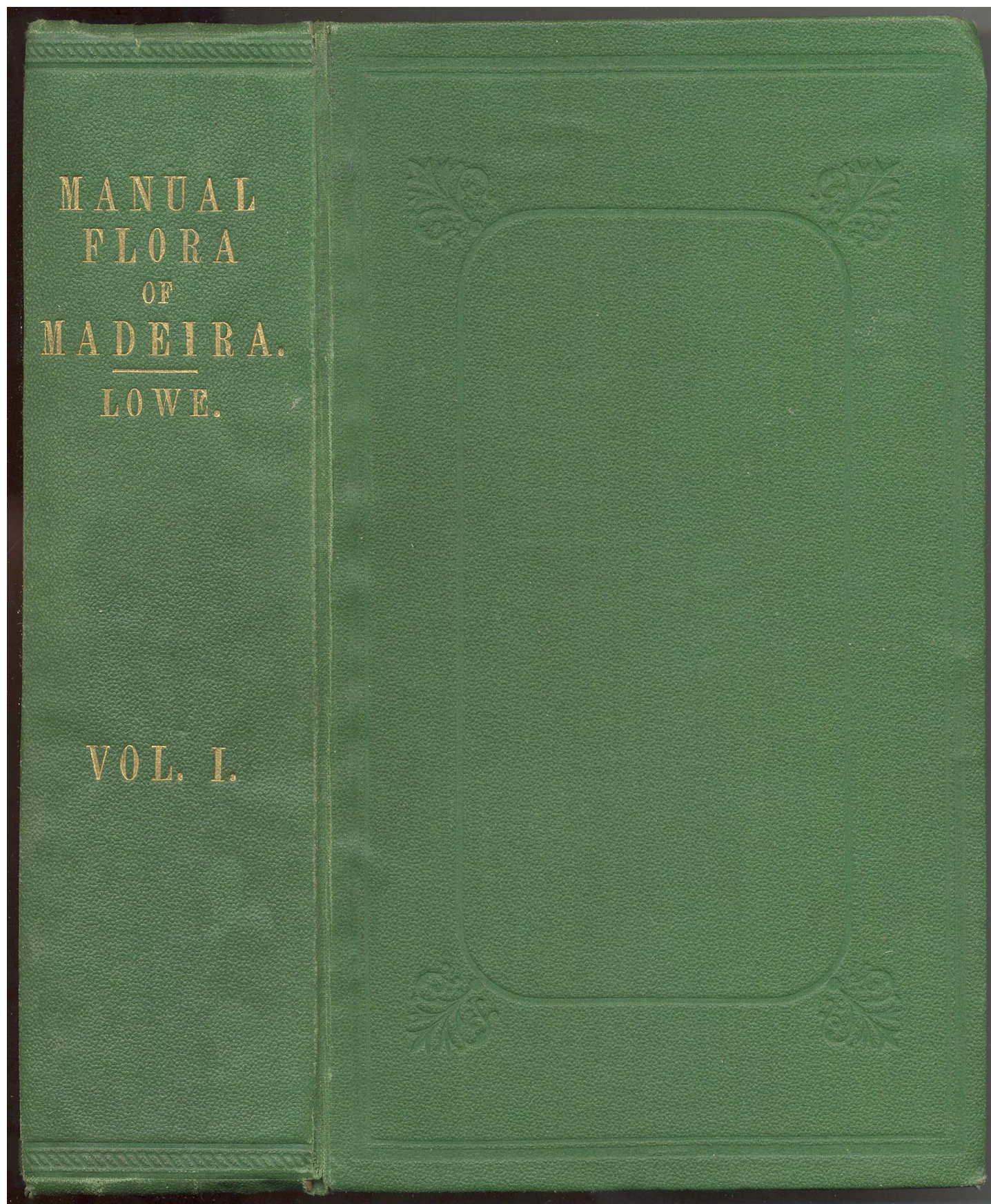


Fig. 4 – *A Manual Flora of Madeira*: front board and spine of the consolidated volume I (case a).

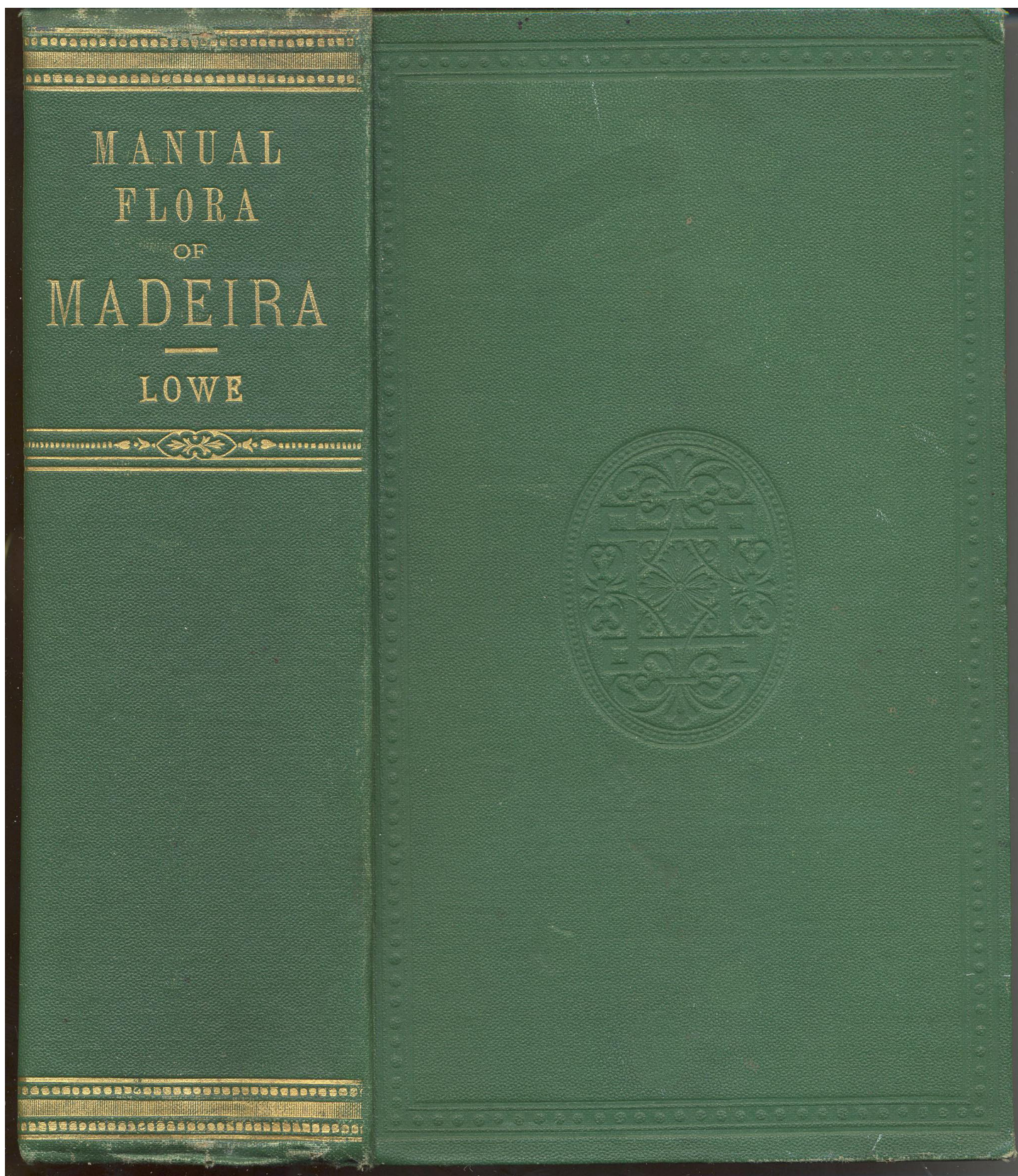


Fig. 5 – *A Manual Flora of Madeira*: front board and spine of the consolidated volume I plus part I of volume II (case c).

natural history, was often favourably remarked upon, although it resulted in a somewhat lengthy text. This prolixity was ameliorated to some degree by his extensive use of abbreviations for a multitude of topics, carefully explained on pages iii-xii. The reviewer for *The Athenaeum* was nevertheless most enthusiastic (ANONYMOUS, 1858):

"It is not a list of the plants of Madeira, with their localities, but a description of every species, with the character of the genera, orders and classes. The descriptions of the plants are fuller and more complete than is usual in manuals of botany, hence it will be found of greater service to those who are entering on the study of botany, or who do not possess in other works an account of the plants referred to."

Part I gained praise as much in Paris as in London, and for similar reasons (ANONYMOUS, 1869b):

"Cet ouvrage est écrit d'une manière spéciale et pratique; négligeant presque la diagnose des genres, suffisamment connus des botanistes auxquels s'adresse son livre, et décrits ailleurs, il insiste longuement sur chaque espèce. Il la caractérise et la commente longuement; il en fait connaître avec soin les synonymes et les localités."

Part II was likewise well-received (ANONYMOUS, 1862b), but again tempered by implied criticism of the delay in publication:

"At length we have a second part of Lowe's Manual Flora of Madeira (Van Voorst) ... Independent of its valuable information on technical Botany, this little volume contains much interesting discussion upon subjects of another kind. Of the latter we give a few examples." They included "Geological Accuracy", "The Wild Parent of the Apple", "The Portugal Laurel" and "Madeira Wood Strawberries".

However, one reviewer of part III could barely conceal his increasing irritation over its tardy publication, but was nevertheless obliged to accept that the painstaking preparation was a contributory factor, and so softened his criticism by a plea for a wider readership (ANONYMOUS, 1864b):

"How long, alas! may we have to wait for the completion of a book of the utmost importance to botanists who are interested in what is sometimes called the Atlantic Flora! ... The necessity even now of being absent from England during the early part of each year is one cause of the small progress made with his Flora; but another is the great care and caution exercised in the preparation

of every part of it ... Happily in this case we can dispense with the recognized privilege of reviewers, and make only one complaint, – viz. again[s]t the very slow rate of publication. We fear that this delay in the issue of the Parts is unavoidable; for Mr Lowe has now again started for a southern climate ... We sincerely hope that our recommendation of this book will lead [to] an extensive sale. No student of the botany of South-western, or even Western, Europe ought to be without it."

Of all the biological monographs that Van Voorst published, *The Flora* seems to be one of the rarest. It is rather difficult to account for this, since it generally attracted good reviews, though not entirely without criticism. The number printed is not known; but there may have been fewer of the later parts than the first, if early subscribers had lost patience with its tardy production. Furthermore, at 3s. 6d. per part, it may appear to have been rather expensive, particularly for an unillustrated work. However, since each part was quite long, the price was not quite so excessive as it at first appears, being one penny for 3 pages. Comparative costs for the parts-issues of Philip Henry Gosse's *Actinologia Britannica* (1s. 6d. per part with coloured plates) and Edward Forbes's *History of British Starfishes* (2s. 6d. per part with wood engravings) were one penny for 1.9 or 1.6 pages, respectively (see WILLIAMS, 2014, 2017).

Volume I, complete in publisher's cloth, was priced at 15s. which was a saving of 2s. 6d. compared to the purchase of the five parts separately. Furthermore, the final consolidation with part I of volume II in cloth was offered at the same price, 15 years after publication commenced. In France, where the work was available from two Paris booksellers, F. Klincksieck and J. Rothschild, volume I was sold for 20 francs (ANONYMOUS, 1869b), equivalent at that time to about 16s. sterling (see R. Edvinsson, URL <http://www.historicalstatistics.org/Currencyconverter.html>, accessed 14 February 2017).

Unfortunately, it seems likely that *The Flora* was not a commercial success – its protracted publication and premature curtailment would certainly have militated against it. Van Voorst apparently sold the stock remaining after Lowe's death to Bernard Quaritch, the well-known London bookseller. This is evidenced by the rather blunt manuscript note inside the front wrapper (page w[2]) of the separate part I of volume II held by Cambridge University Library (shelf-mark MD.30.36): "Note from Publisher | 'Lowes [sic] Flora of Madeira' | Pt. I of vol II was the last published. Author dead. | Quaritch has the stock. | 31. 10. '84".

QUARITCH (1881: 160) opined in his catalogue: "A more correct and complete detailed catalogue of the living plants, actually or heretofore existing in the Madeiras, than has been made; it is the fruit of twenty-six years' labour in the Islands. The Botany of this group, traced by a skilled hand, is of the greatest importance as a test of the variations between the Floras of the great continents of which the Madeiras are the visible connecting links". Admittedly, as Quaritch ultimately obtained the remainder stock, he may have had a vested interest in this fulsome assessment, although it is not known whether he had already acquired the stock as early as 1881. However, perhaps he had, because Gurney & Jackson (the successors to Van Voorst), did not include *The Flora* in their list of Van Voorst titles still available in 1888 (Gurney & Jackson advertisement in RUDOLF, 1889).

As one obituarist of Lowe observed, "His book is a remarkably accurate and minutely painstaking account of the vegetation of the group. It is greatly to be regretted that it is left thus unfinished, as there is probably no botanist with the knowledge of the Madeiran flora which was possessed by Mr. Lowe" (ANONYMOUS, 1874b).

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I am grateful to several librarians and archivists at the following institutions for kind assistance in locating books and other materials for this study: at Cambridge University, the Cory Library, the Herbarium Archive, the Plant Sciences Library and the University Library; the Royal Botanic Gardens, Kew; and the British Library. Christine Bartram was especially helpful in bringing together the copies of *The Flora* held by the several Cambridge botanical libraries. I also thank Dr. Mark Carine for comments on the typescript of this paper.

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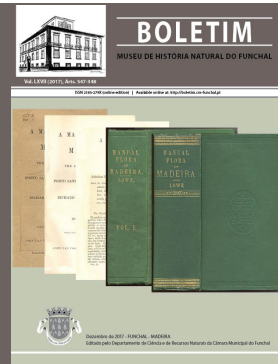
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A checklist of digenean parasites (Platyhelminthes: Digenea) infecting molluscs and fishes in Portuguese waters (Northeast Atlantic)

By G. COSTA ^{1,*}, S. SOARES ², F. CARVALHO ² & E. MELO-MOREIRA ¹

With 1 figure and 1 table

¹ Estação de Biologia Marinha do Funchal, Universidade da Madeira, Cais do Carvão, Promenade da Orla Marítima do Funchal, 9000-107 Funchal, Madeira, Portugal.

* Corresponding author: gcosta@uma.pt

² Departamento de Imuno-Fisiologia e Farmacologia, Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto, Rua Jorge Viterbo Ferreira, 228, 4050-313 Porto, Portugal.

ABSTRACT: The present work is a compilation of the digenean parasites infecting molluscs (gastropods and bivalves), crabs and fishes of the Atlantic coast of Portugal and the Archipelagos of Azores and Madeira, based on literature sources, including research conducted by the present authors. A total of 65 digenea taxa were found, belonging to 24 families, infecting gastropods, bivalves, shore crabs and fishes. The most representative families of digeneans were the Hemiuridae (11 taxa), followed by the Bucephalidae (5 taxa), Opcoelidae (5 taxa) and the Zoogonidae (5 taxa). Hosts, site of infection, sampling locality and life cycle strategy are given when available. Further fields of research on the digenean parasites are suggested.

Keywords: digeneans, gastropods, bivalves, fishes, faunal survey, Portugal, Madeira, Azores, North Atlantic.

RESUMO: A presente revisão pretende compilar os registos publicados de digenéticos parasitas de moluscos (gastrópodes e bivalves), caranguejos e peixes da costa continental Portuguesa, e dos arquipélagos dos Açores e Madeira. Estes registos foram obtidos através de extensa consulta bibliográfica, sendo alguns destes registos resultado de investigação dos presentes autores. Um total de 65 taxa, de digenéticos, organizados por 24 famílias, parasitam diversos organismos marinhos da costa portuguesa. A família mais representativa é a Hemiuridae (11 taxa), seguida de 3 famílias cada uma representada por 5 taxa de digenéticos (Bucephalidae, Opcoelidae, Zoogonidae). Os hospedeiros, o local de amostragem, local de infestação, e ciclo de vida do parasita são indicados sempre que possível. Sugerem-se alguns campos de investigação na temática dos digenéticos parasitas de organismos marinhos.

Palavras-chave: digenéticos, gastrópodes, bivalves, peixes, estudo faunístico, Portugal, Madeira, Açores, Atlântico Norte.

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INTRODUCTION

Taxonomic inventories of marine parasite species are important to determine patterns of geographic distribution, according to depth and to latitudinal gradients (ROHDE, 1993) as well as to inform about the fish hosts migratory routes and the species richness of the ecosystem (POULIN & MORAND, 2000; POULIN *et al.*, 2016). Marine digenean parasites are particularly interesting to elucidate about the species richness of a given ecosystem as they develop through complex life cycles involving two and more hosts with fishes or birds as definitive hosts (MARCOGLIESE, 2002; ZANDER & REIMER, 2002). Portugal has an extensive marine economic exclusive zone (EEZ) in the North-east Atlantic Ocean, encompassing the coastal waters of mainland at the Iberian Peninsula and the Archipelagos of Azores and Madeira. The total coastline of mainland Portugal extends to 943 km, the Madeiran one to 250 km and the Azores coastline to 667 km (CARNEIRO *et al.*, 2014). A number of rocky shore areas and river estuaries in mainland Portugal, sustain a rich diversity of molluscs and fishes, many of which are commercially exploited (INSTITUTO NACIONAL DE ESTATÍSTICA, 2015). Molluscs, both gastropods and bivalves, are common intermediate hosts of digenean parasites, with definitive hosts being either fish or marine birds (CRIBB, 2001; POULIN & CRIBB, 2002). In insular regions, such as in Madeira and Azores Archipelagos, representing oceanic habitats, it is expected that the life cycles of digeneans parasites of marine fishes, include mainly members of the zooplankton as intermediate hosts (KØIE, 1991, 1992) due to the coastal characteristics, with only a few sandy shores, mostly pebbles in the shore areas, and abrupt depth slopes. The island archipelagos of Madeira and Azores are part of the Macaronesian biogeographic region, which includes also the Canary and Cape Vert archipelagos. They have a strong influence of ocean currents from the Mediterranean and the Gulf of Mexico, with some parasite species suggesting these links with those marine regions (GIBSON & COSTA, 1997; COSTA *et al.*, 2013). Furthermore, Madeira lies on the border between temperate and tropical regions (see ROHDE, 1993). Here, it is to expect a mixture of digeneans common to sub-tropical and temperate waters as well as species typical of the Mediterranean (GIBSON & COSTA, 1997). On the other hand, the parasites of the coastal rocky shores and estuaries of mainland Portugal show similarities with parasites found in other European Atlantic coastal habitats and the Mediterranean habitats (SANTOS & EIRAS, 1995; RUSSELL-PINTO *et al.*, 2006; COSTA *et al.*, 2016). Nevertheless, changes in

faunal diversity can be expected, due to the distribution of intermediate and definitive hosts and climate change (see MOURITSEN & POULIN, 2002; THIELTGES *et al.*, 2008; LAFFERTY, 2009; REID & BEAUGRAND, 2012). In particular, due to this last factor, climatic changes, which propitiates invasion of species from tropical areas further north (PALM, 2011; POULIN *et al.*, 2011) it is important to elaborate up to date checklists of parasites and hosts. Earlier studies of digenean parasites in Portugal were those of TENDEIRO (1955) on a description of a new species *Dolichoenterum manteri* (Bucephalidae) from the intestine of conger eels, *Conger conger*. After a lapse of about 40 years, increased research on the occurrence of digeneans in fish and molluscs started (RUSSELL-PINTO, 1990, 1993), with some new species of digeneans described, as well as the elucidation of their life cycles strategies. In the last 20 years, a number of papers have been published with studies of the occurrence, infection dynamics and life cycles of digeneans in Portugal, based on both morphological and molecular approaches (RUSSELL-PINTO *et al.*, 2006; PINA *et al.*, 2007, 2009, 2011a, b; FRANCISCO *et al.*, 2010a, b, 2011), increasing substantially our knowledge about species diversity and life cycle strategies of these parasites. The aim of the present work was to compile the available data of species of digeneans, their life cycle strategies, and the geographical range from mainland Portugal and archipelagos of Azores and Madeira, with a view of providing current research findings on the diversity of this group of parasites, and identify future areas of research to complement our present knowledge on this group.

MATERIALS AND METHODS

Records of digenean parasites of marine organisms (molluscs and fishes mainly and some crabs) were obtained from published scientific literature between 1950 and 2016, our own results and literature records appearing in Web of Science database. The taxonomy of the digenean species is in accordance with GIBSON *et al.* (2002), JONES *et al.* (2005) and accepted taxa in WoRMS (World Register of Marine Species). Fish families and taxa are in accordance with the database FishBase (FROESE & PAULY, 2016). Digenea families are in alphabetical order, with the digenean taxa described in each family in Portuguese waters, their sampling locality, intermediate and definitive hosts (when known) cercarian group, habitat, and life cycle strategy (obtained by experimental study or inferred

from literature). Figure 1 shows the sampling localities, along the mainland Portuguese Atlantic coast and the Archipelagos of Azores and Madeira, of the molluscs and fishes examined for the presence of digenean parasites. Table 1 gives the geographic coordinates of the sampling localities referred in this work.

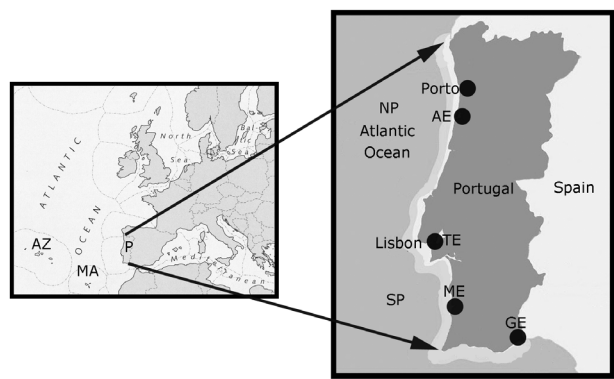


Fig. 1 – Location of the sampling localities along the mainland Portuguese Atlantic coast (P) and the archipelagos of Azores (AZ) and Madeira (MA). (AE) = Aveiro estuary; (TE) = Tagus estuary; (ME) = Mira estuary; (GE) = Guadiana estuary; (NP) = Northern Portuguese coastal waters; (SP) = Southern Portuguese coastal waters.

Table 1 – Geographic coordinates of the sampling localities of digenean hosts.

Sampling locality	Coordinates
Aveiro estuary (AE)	40° 00' N, 8° 50' W
Azores Archipelago (AZ)	36° 55' N-39° 45' N, 25° W-31° 15' W
Guadiana estuary (GE)	37° 12' N, 7° 25' W
Madeira Archipelago (MA)	32° 22' N-33° 8' N, 16° 16' W-17° 16' W
Mira estuary (ME)	37° 43' N, 8° 46' W
Tagus estuary (TE)	39° 30' N, 8° 00' W
Porto, North Portugal (NP)	41° 18' N, 8° 68' W

RESULTS

A total of 65 different taxa of digeneans, from 24 different families, were identified infecting molluscs, crabs and fishes from Portuguese marine waters. Adult digeneans were found in the digestive tract of commercial important fishes belonging to pelagic-neritic and pelagic-oceanic, demersal, benthic and bathypelagic environments. Cercariae were found in gastropods and bivalves, metacercariae in bivalves and in shore crabs mainly. Most studies were conducted in the Aveiro estuary

(AE) and in sandy beaches and rocky shores in Porto (North Portugal, NP), some in river estuaries to the south of Portugal (Tagus, TE; Mira, ME; and Guadiana, GE) and in the coast of Algarve, in the south of Portugal (SP) (Fig. 1). In these near shore habitats it was possible to elucidate the life cycle strategies in many occasions. Nevertheless many life cycles were not studied locally, and they were suggested from literature data obtained elsewhere. A few studies were done in the archipelagos of Madeira (MA) and Azores (AZ), which represent oceanic habitats. In these cases, elucidation of the life cycle strategies of digeneans were based on previous literature published data.

PARASITE HOST LIST

PHYLUM PLATYHELMINTHES Gegenbaur, 1859
SUBPHYLUM NEODERMATA (Ehlers, 1995)
CLASS TREMATODA Rudolphi, 1808
SUBCLASS DIGenea Carus, 1863

FAMILY ACANTHOCOLPIDAE Lühe, 1906

Stephanostomum pristis (Deslongchamps, 1824)
Looss, 1899
Host: *Trisopterus luscus* (Gadidae)
Cercarian group: ophthamoxiphidiocercariae
Habitat: benthopelagic
Sampling locality: unknown since fish were obtained at Lisbon fish market
Site of infection: intestine
Life cycle strategy: gastropods act as first intermediate hosts, metacercariae are found in bivalves and fish muscles, definitive hosts are piscivorous teleosts (KØIE, 1978; BRAY *et al.*, 2005).
References: RODRIGUES *et al.*, 1972.

FAMILY ACCACOELIIDAE Odhner, 1911

Accacladocoelium petasiporum Odhner, 1928
Host: *Pagellus bogaraveo* (Sparidae)
Cercarian group: unknown
Habitat: oceanic, benthopelagic
Sampling locality: Azores Archipelago (AZ)
Site of infection: stomach
Life cycle strategy: The first intermediate host is unknown, metacercariae are common in gelatinous zooplankton (cnidarians and ctenophores), and adults in fish, most typically sunfishes, *Mola mola* (GIBSON *et al.*, 2002).

References: HERMIDA *et al.*, 2013, 2014.

Odhnerium sp. Yamaguti, 1934

Host: *Helicolenus dactylopterus* (Sebastidae)

Cercarian group: not known

Habitat: oceanic, benthopelagic

Sampling locality: Azores Archipelago (AZ)

Site of infection: mesenteries

Life cycle strategy: Like other accacoelids intermediate hosts are planktonic organisms, and the usual definitive hosts are sunfishes, where the parasite occurs in the intestine.

References: SEQUEIRA *et al.*, 2010.

Paraccacladium Bray & Gibson, 1977 (juveniles)

Host: *Trachurus picturatus* (Carangidae)

Cercarian group: not known

Habitat: oceanic, pelagic

Sampling locality: Azores Archipelago (AZ)

Site of infection: digestive tract

Life cycle strategy: Ctenophores and jellyfishes act as intermediate hosts. The adults are typical of deep-water Macrouridae. Its presence on *T. picturatus* was considered accidental.

References: GAEVSKAYA & KOVALEVA, 1985.

Tetrochetus coryphaenae Yamaguti, 1934

Host: *Trachurus picturatus*

Cercarian group: not known

Habitat: oceanic, pelagic

Sampling locality: Azores Archipelago (AZ)

Site of infection: digestive tract

Life cycle strategy: metacercariae are found in planktonic invertebrates such as chaetognaths and ctenophores, and pelagic fish are paratenic hosts. The final host are fishes of the genus *Coryphaena* and *Coryphaenoides*.

References: GAEVSKAYA & KOVALEVA, 1985; BRAY & GIBSON, 1977.

FAMILY APOCREADIIDAE **Skrjabin, 1942**

Homalometron galaicus (= *Apocreadium galaicus*)

SanMartin, Alvarez, Quintero & Paniagua, 1995

Host: *Dicloglossa cuneata*, *Microchirus azevia*,

M. variegatus, *Solea senegalensis* (Soleidae)

Cercarian group: not known

Habitat: coastal waters, benthic

Sampling locality: Atlantic coast of Portugal (NP to SP)

Site of infection: digestive tract

Life cycle strategy: adults in the intestine of marine fishes (JONES *et al.*, 2005). No data about other aspects of the life

cycle are referred in the literature.

References: MARQUES *et al.*, 2006, 2009, 2011.

FAMILY AZYGIIDAE **Lühe, 1909**

Otodistomum veliporum (Creplin, 1837) Stafford, 1894

Host: *Torpedo torpedo* (Torpedinidae)

Cercarian group: furcocyctophorous

Habitat: benthic

Sampling locality: Coast of Algarve (SP)

Site of infection: stomach

Life cycle strategy: this digenean species was first described from the stomach of the deep-water shark, *Hexanchus griseus*. It occurs also in other shark species and in rays. The life cycle includes a gastropod as first intermediate host, fishes can act as paratenic hosts, and elasmobranchs are the final hosts. Metacercariae of *Otodistomum* sp., were recently found in the digestive tract of sole, *Solea solea* and visceral cavity of *Solea kleinii* (MARQUES *et al.*, 2011).

References: TENDEIRO & VALDEZ, 1955.

FAMILY BUCEPHALIDAE **Poche, 1907**

Bucephallus baeri Maillard & Saad-Fares, 1981

Host: *Dicentrarchus labrax* (Moronidae)

Cercarian group: gasterostome

Habitat: coastal sandy shores

Sampling locality: Aveiro estuary (AE)

Site of infection: intestine

Life cycle strategy: the life cycle of this digenean should follow the pattern known for other *Bucephallus* sp. which includes bivalves as first intermediate hosts and benthic or benthopelagic fishes as final hosts (PINA *et al.*, 2009b).

References: SANTOS, 1996.

Bucephallus minimus Stossich, 1887

Host: *Dicentrarchus labrax*

Type of cercaria: gasterostome

Habitat: coastal sandy bottoms

Sampling locality: Aveiro estuary (AE), Douro estuary (Porto, NP)

Site of infection: heart, liver, spleen

Life cycle strategy: cercariae are found in bivalves, metacercariae in fish, such as *Mugil cephalus* (Mugilidae), *Pomatoschistus microps* (Gobiidae), *Sparus aurata* (Sparidae), adults in seabass, *D. labrax* (see FALIEUX & MORAND, 1994).

References: RUSSELL-PINTO, 1993; RUSSELL-PINTO *et al.*, 2006; PINA *et al.*, 2009b.

Dolichoenterum manteri Tendeiro, 1955

Host: *Conger conger* (Congridae)

Cercarian group: not known

Habitat: coastal sandy shores

Sampling locality: Coast of Algarve (Southern Portugal) (SP)

Site of infection: intestine

Life cycle strategy: no data on the life cycle of this digenean is available in the literature. It was only reported once infecting the intestine of conger eels from coastal waters at the south of Portugal.

References: TENDEIRO, 1955.

Prosorhynchus aculeatus Odhner, 1905

Host: *Mytilus galloprovincialis* (Bivalvia, Mytilidae); *Conger conger*

Cercarian group: gasterostome

Habitat: coastal sandy and rocky shores

Sampling locality: Aveiro estuary (AE), Tagus estuary (TE)

Site of infection: stomach, rectum (in fish), branchial arches, muscles (in mussels)

Life cycle strategy: mussels are the first intermediate hosts, metacercariae are found in several fishes (e.g. *Solea solea*) and adults in Conger eels, *Conger conger*.

References: SANTOS & GIBSON, 2002; MARQUES *et al.*, 2006, 2009; DURIEUX *et al.*, 2007b; FRANCISCO *et al.*, 2010a, b, 2012.

P. crucibulum (Rudolphi, 1819) Odhner, 1905

Host: *Mytilus galloprovincialis* (and other *Mytilus* spp.)

Cercarian group: gasterostome

Habitat: sandy and rocky shores

Sampling locality: Aveiro estuary (AE), Tagus estuary (TE)

Site of infection: kidney, stomach, muscles, digestive tract (of fishes) branchial arches (in mussels)

Life cycle strategy: bivalves (*Mytilus* spp.) are the first intermediate hosts, metacercariae are found in rock shore fishes and flatfishes (*Dicologlossa cuneata*, *Solea kleinii*, *S. lascaris*, *S. senegalensis*, *S. solea*), associated with sandy bottoms, and definitive host is conger eel, *C. conger*, although adults of this digenea were additionally found in *Dicentrarchus labrax*. Furthermore metacercariae of *Prosorhynchus* sp. were found in the common goby, *Pomatoschistus microps* (FREITAS *et al.*, 2009; COSTA JL *et al.*, 2012).

References: SANTOS, 1996; SANTOS & GIBSON, 2002; DURIEUX *et al.*, 2007b; MARQUES *et al.*, 2006, 2009; FRANCISCO *et al.*, 2010a, b, 2012.

FAMILY CRYPTOGENIMIDAE Ward, 1917

Acanthostomum Looss, 1899

Host: *Pomatoschistus microps* (Gobiidae)

Cercarian group: biocellate, parapleurolophocercous

Habitat: sandy and rocky shores

Sampling locality: Tagus estuary (TE)

Site of infection: digestive tract

Life cycle strategy: since species of the genus *Timoniella* (previously named *Acanthostomum*) have been found in the same locations, it is possible that the present taxon is a *Timoniella* species (see DURIEUX *et al.*, 2007a, b). The present record refers to the occurrence of metacercariae.

References: COSTA JL *et al.*, 2012.

Timoniella imbutiforme (= *Acanthostomum imbutiforme*) (Molin, 1859) Brooks, 1980

Host: *Solea solea*

Cercarian group: unknown

Habitat: coastal sandy and rocky shores

Sampling locality: Tagus estuary (TE)

Site of infection: muscles

Life cycle strategy: gastropods of the genus *Hydrobia* are the first intermediate hosts, metacercariae are found in muscles of benthic fishes (*Dicentrarchus labrax*, *Solea solea*) and adults in the intestine of conger eels (DURIEUX *et al.*, 2007a).

References: DURIEUX *et al.*, 2007b.

T. prateterita (Looss, 1901) Maillard, 1974

Host: *Dicentrarchus labrax*, *Solea solea*

Cercarian group: biocellate, pleurolophocercous

Habitat: coastal sandy shores

Sampling locality: Aveiro estuary (AE), Tagus estuary (TE)

Site of infection: muscles, intestine

Life cycle strategy: metacercariae found in benthic and benthopelagic fishes such as *Solea solea* and *Dicentrarchus labrax*, adults are parasites of Conger eels, *C. conger*. Nevertheless, SANTOS (1996) and MAILLARD (1976) refer to the occurrence of adults in *D. labrax*.

Reference: SANTOS, 1996; DURIEUX *et al.*, 2007b.

FAMILY DEROGENIDAE Nicoll, 1910

Derogenes varicus (Müller 1784) Looss, 1901

Host: *Dicentrarchus labrax*, *Dicologlossa cuneata*,

Microchirus azevia, *M. variegatus*, *Solea kleinii*, *S. lascaris*, *S. senegalensis*, *Pagellus bogaraveo* (Sparidae) *Platichthys flesus* (Pleuronectidae) *Scophthalmus rombus* (Scophthalmidae)

Cercarian group: cystophorous

Habitat: pelagic, benthopelagic

Sampling locality: Azores Archipelago (AZ), Atlantic coast of North Portugal (NP)

Site of infection: digestive tract, gills

Life cycle strategy: gastropods are first intermediate hosts, calanoid and harpacticoid copepods ingest free-swimming cercariae, small fishes (gobids) and flatfishes harbour immature stages and adults develop in benthopelagic or demersal fishes (KØIE, 1979). This digenean was first known from gastropods as *Cercaria appendiculata*.

References: CARVALHO-VARELA & CUNHA-FERREIRA, 1987; SANTOS, 1996; MARQUES *et al.*, 2006, 2009, 2010, 2011; HERMIDA *et al.*, 2013, 2014.

FAMILY DIPLOSTOMIDAE Poirier, 1886

Diplostomum sp. von Nordmann, 1832

Host: *Platichthys flesus*

Cercarian group: furcocercous

Habitat: coastal sandy shores

Sampling locality: Atlantic coast of North Portugal (NP)

Site of infection: eyes

Life cycle strategy: metacercariae are found in several fish species. Final hosts are marine birds. There are several species of *Diplostomum*, with *D. paracaudum* being the most similar to the present specimens, based on 18S + ITS1 + 5.8S region of the rDNA (see CAVALEIRO *et al.*, 2012).

References: CAVALEIRO *et al.*, 2012.

FAMILY FELLODISTOMIDAE Nicoll, 1909

Lomasoma stephanskii Dollfus, 1960

Host: *Microchirus variegatus*

Cercarian group: furcocercous

Habitat: coastal sandy shores

Sampling locality: Atlantic coast of Portugal (NP)

Site of infection: digestive tract

Life cycle strategy: the life cycle of this digenean is unknown to date (see ALVAREZ *et al.*, 2002). As a fellostomid it is assumed that cercariae are furcocercous.

Reference: MARQUES *et al.*, 2006, 2009, 2011.

Monascus filiformis (Rudolphi, 1819) Looss, 1907

Host: *Trachurus picturatus*

Cercarian group: furcocercous

Habitat: oceanic, benthopelagic and epi-pelagic

Sampling locality: Atlantic coast of Portugal (NP)

Site of infection: intestine

Life cycle strategy: bivalves are first intermediate hosts, small fishes can act as paratenic hosts and several fish species act as definitive hosts. Transmission in coastal habitats appears to be from bivalves to fish, whereas in

off shore habitat requires a fish as transport host. Final hosts are mainly carangids (KØIE, 1979; BRAY & GIBSON, 1980; MARTORELLI & CREMONTE, 1998).

References: HERMIDA *et al.*, 2015.

Proctoeces maculatus (Looss, 1901) Odhner, 1911

Host: *Platichthys flesus*

Cercarian group: furcocercous

Habitat: coastal sandy shores

Sampling locality: Aveiro estuary (AE)

Site of infection: digestive tract

Life cycle strategy: bivalves, such as *Mytilus galloprovincialis* (Mytilidae) as first intermediate hosts, harbouring the cercariae, polychaetes as second hosts and labrids and sparids usually as definitive hosts (ANTAR & GARGOURI, 2016). However, progenetic metacercariae, and adults, were found in gastropods (see DOLLFUS, 1965; LAUCKNER, 1980) and bivalves (*Mytilus edulis*) (STUNKARD & UZMANN, 1959).

References: DIAS & SERRANO, 1972; MARQUES *et al.*, 2009, 2010, 2011.

Tergestia sp. Stossich, 1899

Host: *Trachurus picturatus*

Cercarian group: furcocercous

Habitat: oceanic, epi-pelagic

Sampling locality: Atlantic coast of Portugal (NP)

Site of infection: intestine

Life cycle strategy: cercariae occur in planktonic organisms, pelagic fishes as definitive hosts. *Tergestia laticollis* (Rudolphi, 1819) Stossich 1899 was described from *Trachurus trachurus* (see BRAY & GIBSON, 1980). It is possible that present taxon corresponds to *T. laticollis*.

References: HERMIDA *et al.*, 2015.

FAMILY GYMNOPHALLIDAE Odhner, 1905

Parvatrema minutum (= *Meiogymnophallus minutus*)

Cobbold, 1859

Host: *Cerastoderma edule* (Bivalvia, Cardiidae)

Cercarian group: furcocercous

Habitat: coastal sandy and rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: mantle margin

Life cycle strategy: the cercaria are found in gills of cockles, such as *Scrobicularia plana*, metacercaria in mantle margin of cockles, such as *Cerastoderma edule* and adults in the intestine of marine birds, oystercatchers.

References: RUSSELL-PINTO, 1990; RUSSELL-PINTO & BARTOLI, 1992; RUSSELL-PINTO *et al.*, 1996.

Parvatrema fossarum (= *Meiogymnophallus fossarum*)

Bartoli, 1965

Host: *Cerastoderma edule*

Cercarian group: furcocercous

Habitat: coastal sandy and rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: mantle margin

Life cycle strategy: this digenean should include a gastropod as first intermediate host, and bivalves as second hosts, with adults in the intestine of oystercatchers.

Nevertheless the life cycle is still unknown.

References: RUSSELL-PINTO & BARTOLI, 1992.

Gymnophallus choledochus Odhner, 1900Host: *Cerastoderma edule*

Cercarian group: furcocercous

Habitat: coastal sandy and rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: mantle of the bivalves

Life cycle strategy: bivalves, as *C. edule*, harbour the cercaria and metacercaria. Polychaetes such as *Nereis* spp. can also be infected with metacercaria. The definitive hosts are ducks, *Tadorna tadorna*. Recently RANGEL & SANTOS (2009) found a polychaete, *Diopatra neapolitana*, as second intermediate host of this digenean.

References: RUSSELL-PINTO, 1993.

Parvatrema rebecqui (= *Gymnophallus rebecqui*)

Bartoli, 1983

Host: *Cerastoderma edule*, *C. glaucum*

Cercarian group: furcocercous

Habitat: coastal and sandy rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: mantle

Life cycle strategy: bivalves harbour metacercariae and birds, like the common duck are the definitive hosts. The first intermediate host is still unknown however it is assumed that cercariae belong to the furcocercous type.

References: RUSSELL-PINTO, 1993.

FAMILY HETEROPHYIDAE **Braun, 1901***Cryptocotyle lingua* Creplin, 1825Host: *Pomatoschistus microps*

Cercarian group: lophocercous

Habitat: coastal and sandy coastal shores

Sampling locality: In the Aveiro estuary (AE), and other estuaries in central and southern Portugal

Site of infection: digestive tract

Life cycle strategy: cercariae develop in gastropods of the genus *Littorina*, metacercariae are found in several fishes (e.g. *Pomatoschistus microps*, *Pleuronectes platessa*, *Solea solea*) and marine fish eating birds are the definitive hosts (JAMES, 1968; LAUCKNER, 1980).

Reference: CARVALHO VARELA *et al.*, 1981; FREITAS *et al.*, 2009; COSTA JL *et al.*, 2012.

FAMILY HAPLOSPLANCHNIDAE **Poche, 1926***Schikhobalotrema longivesiculatum* Orecchia & Paggi, 1975Host: *Parablennius parvicornis* (Blenniidae)

Cercarian group: biocellate, distomatous cercariae

Habitat: rocky shores

Sampling locality: Madeira Archipelago (MA)

Site of infection: intestine

Life cycle strategy: the life cycle is currently unknown. It is possible that gastropods are first intermediate hosts and several marine fishes are definitive hosts. An interesting feature of the life cycle of these haploplanchnids is that the metacercariae encyst on vegetation and herbivorous fishes are the final hosts. The species was first described from *Blennius sanguinolentus* (see ORECCHIA & PAGGI, 1975).

References: GIBSON & COSTA, 1997.

FAMILY HAPLOPORIDAE **Nicoll, 1914***Haploporus benedeni* Stossich, 1887Host: *Mugil cephalus* (Mugilidae)

Cercarian group: gymnocephalous

Habitat: coastal sandy shores, estuarine

Sampling locality: coastal waters of Portugal

Site of infection: digestive tract

Life cycle strategy: the life cycle of this digenean includes gastropods of the superfamily Rissooidea, and the definitive hosts are estuarine and freshwater herbivorous fishes (OVERSTREET & CURRAN, 2005).

Reference: CARVALHO VARELA *et al.*, 1981.

FAMILY HEMIURIDAE **Looss, 1899***Ectenurus lepidus* Looss, 1907Host: *Solea solea*, *Trachurus picturatus*, *T. trachurus*

Cercarian group: cystophorous

Habitat: oceanic, pelagic, sandy shores

Sampling locality: Atlantic coast of Portugal (NP), Azores Archipelago (AZ)

Site of infection: stomach

Life cycle strategy: gastropods as first intermediate hosts,

second intermediate hosts planktonic organisms such as copepods and chaetognaths (metacercariae) and fishes as definitive hosts (GIBSON & BRAY, 1986).

Reference: GAEVSKAYA & KOVALEVA, 1985; CARVALHO VARELA & CUNHA-FERREIRA, 1987; MACKENZIE *et al.*, 2008; HERMIDA *et al.*, 2015.

Ectenurus virgulus Linton, 1910

Host: *Trachurus picturatus*

Cercarian group: cystophorous

Habitat: oceanic, pelagic

Sampling locality: Azores Archipelago (AZ)

Site of infection: stomach

Life cycle strategy: gastropods as first intermediate hosts, second intermediate hosts planktonic organisms such as copepods and chaetognaths (metacercariae) and fishes as definitive hosts (GIBSON & BRAY, 1986).

Reference: GAEVSKAYA & KOVALEVA, 1985.

Glomerocirrus macrouri (Gaevskaya, 1975)

Gaevskaya, 1979

Host: *Pagellus bogaraveo*

Cercarian group: cystophorous

Habitat: benthopelagic

Sampling locality: Northern Portuguese Atlantic coast (NP)

Site of infection: stomach

Life cycle strategy: although the life cycle is not known it is suggested it follows the pattern of other hemiurids, having as first intermediate hosts planktonic invertebrates and benthopelagic fishes as definitive hosts (see GIBSON & BRAY, 1986).

Reference: HERMIDA *et al.*, 2013, 2014.

Hemiurus appendiculatus (Rudolphi, 1802) Looss, 1899

Host: *Alosa alosa*, *A. falax* (Clupeidae) *Pomatoschistus microps*

Cercarian group: cystophorous

Habitat: estuarine, coastal sandy bottoms

Sampling locality: Atlantic coast of Portugal, and adjacent the river estuaries

Site of infection: stomach

Life cycle strategy: as other hemiurids should include gastropods as first intermediate hosts, metacercariae in planktonic invertebrates and fishes as definitive hosts (GIBSON & BRAY, 1986).

Reference: TENDEIRO & VALDEZ, 1955; RODRIGUES *et al.*, 1972; COSTA JL *et al.*, 2012.

Hemiurus communis Odhner, 1905

Host: *Dicentrarchus labrax*, *Pagellus bogaraveo*, *Solea solea*

Cercarian group: cystophorous

Habitat: coastal sandy bottoms

Sampling locality: Northern Portuguese Atlantic coast (NP)

Site of infection: stomach

Life cycle strategy: gastropods are first intermediate hosts, free swimming cercariae invade second intermediate hosts, calanoid copepods, and benthic demersal fishes are the definitive hosts.

Reference: CARVALHO VARELA & CUNHA-FERREIRA, 1987; SANTOS, 1996; HERMIDA *et al.*, 2013, 2014.

Hypohepaticola Yamaguti, 1934

Host: *Helicolenus dactylopterus* (Sebastidae)

Cercarian group: unknown

Habitat: coastal waters, benthopelagic

Sampling locality: Atlantic coast of Portugal

Site of infection: digestive tract

Life cycle strategy: although the life cycle is unknown, the diet of *Helicolenus dactylopterus*, a benthic deep-water fish, is based on crustaceans and fishes, which suggests that intermediate hosts could be benthic crustaceans.

Reference: SEQUEIRA *et al.*, 2010.

Lecithochirium furcolabiatum (Jones, 1933) Dawes, 1947

Host: *Gibbula umbilicalis* (Gastropoda, Trochidae), *Conger conger*, *Lipophrys pholis* (Blenniidae).

Cercarian group: cystocercous

Habitat: coastal sandy and rocky shores, oceanic

Sampling locality: Northern Portuguese Atlantic coast (NP)

Madeira Archipelago (MA)

Site of infection: gonads (cercariae), mesenteries (metacercariae), stomach (adult)

Life cycle strategy: cercariae in hepatopancreas and gonads of gastropods, in copepods (2nd intermediate hosts), metacercariae in rock pool fishes (*Lipophrys pholis*, *Pomatoschistus microps*), adults in conger eels, *C. conger* and other fishes.

References: SANTOS & EIRAS, 1995; COSTA *et al.*, 2009, 2016.

L. grandiporum (= *L. fusiforme* Lühe, 1901) (Rudolphi, 1819) Lühe, 1901

Host: *Conger conger*

Cercarian group: cystophorous

Habitat: benthic rocky shores

Location: Madeira Archipelago

Site of infection: stomach

Life cycle strategy: *Lecithochirium grandiporum* was revised by BARTOLI & GIBSON (2007) in moray eel, *Muraena helena* (Muraenidae). It was concluded that previously described

species *L. fusiforme* from conger eels was a junior synonym of *L. grandiporum*. This taxon thus occurs in conger eels and moray eels.

References: TENDEIRO & VALDEZ, 1955; COSTA *et al.*, 2009.

L. musculus (Looss, 1907) Nasir & Diaz, 1971

Host: *Aphanopus carbo* (Trichiuridae), *Dicentrarchus labrax*, *Conger conger*

Cercarian group: cystophorous

Habitat: oceanic, bathypelagic, benthic rocky shores

Sampling locality: Azores Archipelago (AZ), Madeira Archipelago (MA), Aveiro estuary (AE)

Site of infection: digestive tract, stomach, intestine

Life cycle strategy: although the life cycle is unknown, it is suggested that gastropods act as first intermediate hosts, while free swimming cercariae infect planktonic copepods, which transmit the parasite to gobiids such as *Pomatoschistus microps* (metacercariae) and to the definite hosts. Its occurrence in a deep-water fish (*A. carbo*) could be an accidental infection since this digenean has been described from benthic fishes.

References: SANTOS, 1996; FREITAS *et al.*, 2009; COSTA *et al.*, 2009; SANTOS *et al.*, 2009; COSTA JL *et al.*, 2012.

L. rufoviridae (Rudolphi, 1819) Lühe, 1901

Host: *Arnoglossus laterna* (Bothidae), *Citharus linguatula* (Citharidae), *Conger conger*, *Dicologlossa cuneata*, *Lepidorhombus boscii* (Scophthalmidae), *Microchirus azevia*, *Platichthys flesus*, *Scophthalmus maximus*, *S. rombus* (Scophthalmidae)

Cercarian group: cystophorous

Habitat: benthic coastal waters, rocky shores

Sampling locality: Northern Portuguese Atlantic coast (NP)

Site of infection: digestive tract

Life cycle strategy: this digenean is a parasite characteristic of eels and conger eels, although it occurred also in different flatfish species. The low prevalence of this digenean in the examined flatfishes suggests that they are not the usual definitive hosts (see GIBSON & BRAY, 1986).

References: TENDEIRO & VALDEZ, 1955; MARQUES *et al.*, 2006, 2009, 2010, 2011.

Lecithocladium excisum (Rudolphi, 1819) Lühe, 1901

Host: *Pagellus bogaraveo*, *Scomber scombrus*, *S. colias* (Scombridae), *Trachurus picturatus*

Cercarian group: cystophorous

Habitat: oceanic, epi-pelagic and benthopelagic

Sampling locality: Azores Archipelago (AZ), Atlantic coast of Portugal (NP and SP)

Site of infection: stomach

Life cycle strategy: cercariae in benthic invertebrates such as harpacticoid copepods as first intermediated hosts, polychaetes and ctenophores act as second intermediate hosts, harbouring the metacercariae, pelagic fishes as definitive hosts (KØIE, 1991).

References: GAEVSKAYA & KOVALEVA, 1985; REGO *et al.*, 1985; SHUKHGALTER, 2004; HERMIDA *et al.*, 2013, 2014.

FAMILY HIMASTHLIDAE Odnher, 1910

Himasthla quissetensis (Miller and Northup, 1926)

Stunkard, 1938

Host: *Tritia reticulata* (= *N. reticulatus*) (Gastropoda, Nassariidae), *Cerastoderma edule* (Bivalvia, Cardiidae)

Cercarian group: leptocercous

Habitat: coastal sandy shores

Sampling locality: Aveiro estuary (AE)

Site of infection: mantle of *C. edule*

Life cycle strategy: the life cycle was studied by Stunkard (1938) from molluscs and birds of Woods Hole (USA). The cercariae found in the gastropod *Nassa obsoleta*, metacercariae are found in gills, mantle and foot of several bivalves and adults in herring gull, *Larus argentatus*.

Reference: RUSSELL-PINTO, 1993; RUSSELL-PINTO *et al.*, 2006; RATO *et al.*, 2009.

Himasthla elongata (Mehlis, 1831) Dietz, 1909

Host: *C. edule*

Cercarian group: leptocercous

Habitat: sandy and rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: foot of *C. edule*

Life cycle strategy: metacercariae were found encysted in the foot of the second host, *C. edule*. Probably the first intermediate host is a gastropod and the definitive host a coastal marine bird.

References: RUSSELL-PINTO *et al.*, 2006.

Himasthla interrupta Loos-Frank, 1967

Host: *C. edule*

Cercarian group: leptocercous

Habitat: coastal sandy and rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: mantle and foot

Life cycle strategy: metacercariae were found encysted in the mantle and foot of the second host, *C. edule*. The definitive hosts are birds from the family Laridae.

References: RUSSELL-PINTO *et al.*, 2006.

FAMILY HIRUDINELLIDAE **Dollfus, 1932**

Botulus microporus (Monticelli, 1889) n. comb.

Host: *Alepisaurus ferox* (Alepisauridae)

Cercarian group: unknown

Habitat: oceanic, epi-pelagic to bathypelagic

Sampling locality: Madeira Archipelago (MA)

Site of infection: intestine

Life cycle strategy: The life cycle is unknown. Adults are parasites in the stomach of *Alepisaurus* spp. It was first described from Madeira Archipelago but it occurs in other regions of the North Atlantic and the Pacific Ocean (see GIBSON & BRAY, 1977).

Reference: unpublished results of present authors.

Lampritrema miescheri (Zschokke, 1890) Margolis, 1962

Host: *Trachurus picturatus*

Cercarian group: unknown

Habitat: oceanic, epi- pelagic

Sampling locality: Azores Archipelago (AZ)

Site of infection: digestive tract, stomach, gills

Life cycle strategy: adults are parasites of the stomach of fishes, and sometimes of the gills. Immature specimens have been found in salmonids (GIBSON & BRAY, 1977).

References: GAEVSKAYA & KOVALEVA, 1985.

FAMILY LEPOCREADIIDAE **Odhner, 1905**

Clavogalea trachinoti (Fischthal and Thomas, 1968) Bray & Gibson, 1990

Host: *Scomber colias*

Cercarian group: cystophorous

Habitat: oceanic, epipelagic

Sampling locality: Madeira Archipelago (MA)

Site of infection: stomach, digestive tract

Life cycle strategy: the life cycle was studied experimentally by KØIE (1991). Cercariae collected from gastropods were infective to copepods and metacercariae were developed. Metacercariae were also found in naturally infected ctenophores and holoplanktonic polychaetes, *Tomopteris helgolandica*, invertebrates (ctenophores and chaetognaths), which agrees well with the diet of mackerels (KØIE, 1975, 1991).

References: COSTA *et al.*, 2011.

Lepocreadium album Stossich, 1890

Host: *Pagellus bogaraveo*

Cercarian group: *Cercaria setifera*, trilocercous

Habitat: oceanic, benthopelagic and coastal sandy shores

Sampling locality: Azores Archipelago (AZ), Aveiro estuary (AE)

Site of infection: digestive tract

Life cycle strategy: the life cycle of lepopocreadiids includes cercariae trilocercous (tailed with setae), which are parasites of molluscs, metacercariae infect polychaetes, gastropods and bivalves, also ctenophores. *Cercaria setifera* was found in the gastropod *Tritia reticulata* (= *Nassarius reticulatus*) in Aveiro estuary. Adults may infect benthic fishes (flatfishes) or benthopelagic fishes (*P. bogaraveo*) (see HASSANINE, 2006; SOARES, 2015).

Reference: RUSSELL-PINTO *et al.*, 2006; HERMIDA *et al.*, 2013, 2014; SOARES, 2015.

Opechona bacillaris (Molin, 1859) Dollfus, 1927

Host: *Scomber scombrus*, *Scomber colias*

Cercarian group: ophthalmotrichocercous

Habitat: oceanic, epi-pelagic

Sampling locality: Azores Archipelago (AZ); Atlantic coast of South Portugal (SP)

Site of infection: digestive tract, stomach, intestine

Life cycle strategy: gastropods of the genus *Tritia* (= *Nassarius*) are the first intermediate hosts. Metacercariae have been found in planktonic invertebrates such as ctenophores and chaetognaths. Adults are developed in a range of pelagic fishes (KØIE, 1975; BRAY & GIBSON, 1990).

References: RODRIGUES *et al.*, 1972; REGO *et al.*, 1985; SHUKHGALTER, 2004.

Prodistomum orientale (Layman, 1930) Bray & Gibson, 1990

Host: *Scomber colias*

Cercarian group: trilocercous

Habitat: oceanic, epi-pelagic

Sampling locality: Madeira Archipelago (MA)

Site of infection: digestive tract

Life cycle strategy: although the life cycle was not studied to date, it probably follows the pattern for other lepopocreadiids as described for *Opechona* (BRAY & GIBSON, 1990).

References: COSTA *et al.*, 2011.

FAMILY MICROPHALLIDAE **Travassos, 1920**

Gynaecotyla adunca (Linton 1905) Yamaguti 1934

Host: *Tritia reticulata*, *Carcinus maenas* (Decapoda, Carcinidae)

Cercarian group: leptocercous xiphidiocercaria

Habitat: coastal sandy and rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: hepatopancreas of *T. reticulata*, antennal

glands of *C. maenas*

Life cycle strategy: gastropods of the genus *Tritia* harbor the cercariae and crabs are the second intermediate hosts, where the metacercariae develop. Birds are definitive hosts. This digenea was previously classified as "*Cercaria seviliana*". A new second host, the crab, *Polybius henslowii*, collected from Aveiro estuary, was found infected with metacercariae of this digenean in 2015 (SOARES, 2015). This species was referred as *Gynaecotyla longiintestinata* Leonov, 1958 in RUSSELL-PINTO & BARTOLI (2002).

References: RUSSELL-PINTO & BARTOLI, 2002; PINA *et al.*, 2007.

Maritrema portucalensis Pinto, Russell-Pinto & Rodrigues, 2011

Host: *Carcinus maenas*

Cercarian group: ophthelmoxiphidiocercous

Habitat: coastal sandy rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: metacercariae in gills of crabs

Life cycle strategy: cercariae are found in gastropods, namely *Hydrobia ulvae*, metacercariae are parasites of crabs, namely *Carcinus maenas*, and adults developed in marine birds.

References: PINA *et al.*, 2011a.

Microphallus primas Jägerskiöld, 1908

Host: *Carcinus maenas*

Cercarian group: ophthelmoxiphidiocercaria

Habitat: coastal sandy and rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: hepatopancreas, gonads

Life cycle strategy: cercariae are found in gastropods, *Hydrobia ulvae*, metacercariae in crabs, *C. maenas* and adults develop in the intestine of marine birds, *Larus cachinnans* (SAVILLE & IRWIN, 2005; SANMARTIN *et al.*, 2005).

References: PINA *et al.*, 2011b.

FAMILY MONORCHIIDAE Odhner, 1911

Monorchis parvus Looss, 1902

Host: *C. edule*

Cercarian group: unknown

Habitat: coastal sandy and rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: Several tissues of the *C. edule* infected with cercariae and metacercariae

Life cycle strategy: the life cycle was developed experimentally by BARTOLI *et al.* (2000). *Diplodus sargus* (Sparidae) was successfully infected with metacercariae

collected from *C. edule* and adults were found in the intestine of this fish.

References: RUSSELL-PINTO *et al.*, 2006.

FAMILY OPECOELIDAE Ozaki, 1925

Cainocreadium labracis (Dujardin, 1845) Nicoll, 1909

Host: *Gibbula umbilicalis* (Gastropoda, Trochidae); *D. labrax*

Cercarian group: cotylocercous

Habitat: coastal sandy and rocky shores

Sampling locality: Atlantic coast of North Portugal (NP)

Site of infection: gonads and hepatopancreas of gastropod, intestine of fish.

Life cycle strategy: the life cycle includes the topshell *G. umbilicalis* and other topshells of this genus as first intermediate hosts, fishes of the families Gobiidae and Syngnathidae are infected with metacercariae on the fins and skin and the final host is *D. labrax* (MAILLARD, 1971; BORN-TORRIGOS *et al.*, 2012, 2014).

References: SANTOS, 1996; COSTA *et al.*, 2016.

Helicometra fasciata (Rudolphi, 1819) Odhner, 1902

Host: *Lepidorhombus boscii* (Scophthalmidae), *Lipophrys pholis* (Blenniidae)

Cercarian group: cotylocercous

Habitat: coastal sandy and rocky shores

Sampling locality: North Atlantic coast of Portugal (NP)

Site of infection: digestive tract, intestine

Life cycle strategy: cercariae develop in gastropods, metacercariae in shrimps, adults in several fish species.

References: SANTOS & EIRAS, 1995; MARQUES *et al.*, 2006, 2009, 2010, 2011.

Macvicaria soleae (Dujardin, 1845) Gibson & Bray, 1982

Host: *Dicoglossa cuneata*, *Microchirus azevia*, *M. variegatus*, *Platichthys flesus*, *Solea lascaris*, *S. senegalensis*, *S. solea*

Cercarian group: cotylocercous

Habitat: coastal sandy and rocky shores

Sampling locality: Atlantic coast of Portugal

Site of infection: digestive tract of fish hosts

Life cycle strategy: the life cycle starts with cercarial development in gastropods, which can also function as second intermediate hosts, as the cercariae have a sit- and wait behavior, and the final hosts are fishes (BORN-TORRIGOS *et al.*, 2014).

References: DURIEUX *et al.*, 2007a, b; MARQUES *et al.*, 2006, 2009, 2010, 2011.

Pachycreadium carnosum (Rudolphi, 1819)

Cortini & Ferretti, 1959

Host: *Pagellus bogaraveo*

Cercarian group: unknown

Habitat: oceanic, benthopelagic

Sampling locality: Azores Archipelago (AZ), Madeira Archipelago (MA)

Site of infection: pyloric caeca, intestine

Life cycle strategy: this digenean seems to be specific of Sparidae. MORATO *et al.* (2001) identified only one species of gastropod in the diet of *P. bogaraveo* from the Azores Archipelago, *Diacria trispinosa*, occurring in 6.3% of examined stomachs. If this is a first intermediate host candidate, it could explain the low prevalence of this digenean in this fish host.

References: HERMIDA *et al.*, 2013, 2014.

Pycnadenoides senegalensis Fischthal & Thomas, 1972

Host: *Pagellus bogaraveo*

Cercarian group: unknown

Habitat: oceanic, benthopelagic

Sampling locality: Azores Archipelago (AZ), Atlantic coast of Portugal

Site of infection: pyloric caeca, intestine

Life cycle strategy: no data is presently available about the life cycle of this digenean. Gastropods and fishes could act as first and second intermediate hosts. Since the prevalence is higher in coastal waters of Portugal, it appears that the abundance of intermediate hosts is higher here. Furthermore this parasite was found in the Western Mediterranean in sparid fishes (BARTOLI *et al.*, 1989), and mainland Portugal digenean species show strong connections with the western Mediterranean digenean fauna (GIBSON & COSTA, 1997; MARQUES *et al.*, 2009).

Reference: HERMIDA *et al.*, 2013, 2014.

FAMILY RENICOLIDAE Dollfus, 1939

Renicola roscovitus Stunkard, 1932

Host: *Cerastoderma edule*

Cercarian group: leptocercous

Habitat: coastal sandy and rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: palps of *C. edule*

Life cycle strategy: this digenean infects gastropods of the genus *Littorina*, where cercaria develop, the second host are bivalves, (in the present study metacercariae were found in *C. edule*), and the definitive hosts are marine birds (LAUCKNER, 1980, 1983).

References: RUSSELL-PINTO *et al.*, 2006.

FAMILY STRIGEIDAE Railliet, 1919

Cardiocephaloides longicollis (Rudolphi, 1819) Dubois, 1982

Host: *Tritia reticulata*

Cercarian group: furcocercous

Habitat: coastal sandy and rocky shores

Sampling locality: Aveiro estuary (AE)

Site of infection: digestive gland

Life cycle strategy: gastropods such as *T. reticulata* are first intermediate hosts infected with cercariae, and birds are the definitive hosts. SANMARTIN *et al.* (2005) found adults of this digenean in the marine bird, *Larus cachinnans*. In RUSSELL-PINTO *et al.* (2006) this taxon was classified as "*Cardiocephallus longicollis*".

References: RUSSELL-PINTO *et al.*, 2006.

FAMILY SYNCOELIIDAE Looss, 1899

Copiatestes filiferus (= *Syncoelium filiferum*) (Leuckart in Sars, 1885) Gibson & Bray, 1977

Host: *Trachurus picturatus*

Cercarian group: unknown

Habitat: oceanic, epi-pelagic

Sampling locality: Azores Archipelago (AZ)

Site of infection: digestive tract

Life cycle strategy: this parasite occurs in several fish species. Metacercariae have been found in euphausiid crustaceans, and in some occasions free floating metacercariae were found (see GIBSON & BRAY, 1977). The usual site of infection is the buccal cavity and gill-arch of fishes.

References: GAEVSKAYA & KOVALEVA, 1985.

FAMILY ZOOGONIDAE Odhner, 1902

Brachyenteron helicoleni Bray & Kuchta, 2006

Host: *Pagellus bogaraveo*

Cercarian group: unknown

Habitat: oceanic, benthopelagic

Sampling locality: Atlantic coast of Portugal

Site of infection: intestine

Life cycle strategy: *Brachyenteron helicoleni* has been described as a deep-water parasite infecting *Helicolenus dactylopterus* (BRAY & KUCHTA, 2006). *P. bogaraveo* extends its depth range to 700 m deep, and consumes myctophids and other prey typical of deep-waters (MORATO *et al.*, 2001). It is therefore to expect that it would be infected by parasite species occurring in deep-waters.

References: HERMIDA *et al.*, 2013, 2014.

Diptherostomum vividum (Nicoll, 1912) Bray & Gibson, 1986

Host: *Pagellus bogaraveo*

Cercarian group: unknown

Habitat: oceanic, benthopelagic

Sampling locality: Atlantic coast of Portugal (AP) and Madeira Archipelago (MA)

Site of infection: intestine

Life cycle strategy: apparently it is a rare species, described from the blackspot seabream only (see BRAY & GIBSON, 1986).

References: HERMIDA *et al.*, 2013, 2014.

D. brusinae (Stossich, 1888) Stossich, 1903

Host: *Tritia reticulata*, *Cerastoderma edule*, *Mytilus galloprovincialis*, *Diplodus sargus* (Sparidae)

Cercarian group: tailless xiphidiocercaria

Habitat: coastal sandy shores

Sampling locality: Aveiro estuary (AE)

Site of infection: digestive gland of gastropods, intestine of fishes

Life cycle strategy: gastropods are the first intermediate hosts, metacercariae can be found in bivalves, *Cerastoderma edule*, and in mussels, *Mytilus galloprovincialis*. Adults are parasites of the intestine of fishes. However in several occasions it was found that gastropods can be first and second intermediate hosts, and additionally cercariae can encyst in plants, hydroids and sponges. Sparidae is one of the families elected as definitive hosts, but other fish families are definitive hosts such as Labridae and Gobiidae (see BRAY & GIBSON, 1986).

References: RUSSELL-PINTO, 1990; RUSSELL-PINTO & BOWERS, 1998; RUSSELL-PINTO & BARTOLI, 2002; RUSSELL-PINTO *et al.*, 2006; PINA *et al.*, 2009a; FRANCISCO *et al.*, 2010, 2011.

Zoogonoides viviparus (Olsson, 1868) Odhner, 1902

Host: *Pomatoschistus microps*

Cercarian group: tailless xiphidiocercaria

Habitat: coastal sandy shores and estuaries

Sampling locality: Aveiro (AE), Tagus (TE), Mira (ME) and Guadiana (GE) estuaries.

Site of infection: digestive tract

Life cycle strategy: the first intermediate hosts are gastropods, metacercariae can be found in gastropods, bivalves, echinoderms, and polychaetes, and adults are parasites of the intestine of fishes from different families, all of them of benthic fishes (BRAY & GIBSON, 1986).

References: COSTA JL *et al.*, 2012.

Zoogonus rubellus (Olsson, 1868) Odhner, 1902

Host: *Dicologlossa cuneata*, *Platichthys flesus*, *Solea*

senegalensis

Type of cercaria: tail-less xiphidiocercaria

Habitat: coastal sandy shores

Sampling locality: Southern Atlantic coast of Portugal (SP)

Site of infection: digestive tract

Life cycle strategy: gastropods are first intermediate hosts and annelids the second hosts. Limpets and echinoderms can also be second hosts. Pleuronectiformes and Perciformes seem to be the fish families, which most likely act as definitive hosts (BRAY & GIBSON, 1986).

References: MARQUES *et al.*, 2006, 2009, 2010, 2011.

DISCUSSION

The present checklist compiles the presently known digenea taxa, found in molluscs, crabs and fishes from Portuguese marine zones. However, we are aware and hope, that more new taxa will be added to this checklist in the near future, due to the increased interest of investigations, in the field of marine parasitology. Some digeneans hereby referred are true parasites of their definitive hosts, others can be regarded as accidental infections. Such is the case of *Accacladocoelium* sp. which is a digenean taxon typical of sunfishes (GAEVSKAYA, 2002; AHUIR-BARAJA *et al.*, 2015) with gelatinous zooplankton acting as intermediate hosts (BRAY & GIBSON, 1977). The occurrence of *Accacladocoelium petasiporum* in *P. bogaraveo* from the Azores Archipelago appears to be an accidental infection (HERMIDA *et al.*, 2014) and indicates that both the intermediate and final hosts are available in that region. *Glomerocirrus macrouri* is a typical digenean of macrourid, which explains the very low prevalence in *P. bogaraveo*, a sparid (BRAY & GIBSON, 1986; HERMIDA *et al.*, 2014). Many of the digeneans hereby reported occur in several fish species, they are generalists, some show family specificity, whereas others may be host specific. Perhaps this late case applies to the bucephalid, *Dolichoenterum manteri*, which was found only once in conger eels by TENDEIRO (1955). Some digeneans were not identified to species level and thus require further study including molecular characterization. For example, *Tergestia* sp. found in *T. picturatus*, could be *T. laticollis* (Rudolphi, 1819) Stossich, 1899, which is a digenean occurring in the intestine of horse mackerels (BRAY & GIBSON, 1980). These authors referred to a *Cercaria kenti* that could represent the cercarial form of this digenean, and was found off the coast of Portugal. To link the cercarial type with the adult form it is necessary to collect fresh specimens and to use molecular approaches (BORN-TORRIGOS *et al.*, 2012).

Many digenean parasites share the first intermediate host, but show a diversification of their transmission pathways and final hosts. Such is the case of the gastropod *Tritia reticulata* (= *Nassarius reticulatus*) which is parasitized by cercariae of *Cardiocephaloides longicollis* (referred as *Cardiocephallus longicollis* by RUSSELL-PINTO *et al.*, 2006), *Diphtherostomum brusinae*, *Gynaecotyla adunca*, *Himasthla quissetensis*, and *Lepocreadium album* (RUSSELL-PINTO *et al.*, 2006; RATO *et al.*, 2009; SOARES, 2015), *Littorina littorea* parasitized with at least 8 digenean taxa (JAMES, 1968; COSTA *et al.*, 2016) and *Gibbula umbilicalis* with at least 2 digenean taxa (BORN-TORRIGOS *et al.*, 2012; COSTA *et al.*, 2016). Adults of these digenean species complete their development in different final hosts. This diversity of transmission pathways ensures success of survival of the parasite and shows adaptative strategies of the parasites to their environmental conditions (BUSH *et al.*, 2001; ESCH *et al.*, 2002; MARCOGLIESE, 2002). High prevalences of microphallid digeneans in gastropods and benthic crustaceans, for example, suggested that seabirds were common in the food web (ZANDER *et al.*, 2000; MOURITSEN & POULIN, 2002). The digenean complex life cycles, presenting more than one intermediate host, and paratenic hosts, point to adaptations of the parasite, to a very dilute environment, such as an oceanic habitat, where the encounter of a parasite and its suitable host, requires more effort (MARCOGLIESE, 2002). In some occasions, infection with digenean cercarial stages, leads to castration due to heavy infestation of gonads and replacement of reproductive tissue by parasites (FREDENSBORG *et al.*, 2005; HASSINE, 2006; RATO *et al.*, 2009). This has been observed in *Littorina littorea* (HUXHAM *et al.*, 1993; MOURITSEN *et al.*, 1999; COSTA *et al.*, 2016) and in *Tritia reticulata* (RATO *et al.*, 2009). Behaviour changes can also occur due to parasites (POULIN, 1999; DAVIES & KNOWLES, 2001). The development of molecular approaches to the study of digenean parasites, has contributed to the linking and classification of previous unknown taxa such was the case of *Cercaria sevilla* (RUSSELL-PINTO & BARTOLI, 2002) now known as *Gynaecotyla adunca* (see PINA *et al.*, 2007), and *Cercaria setifera* now known as *Lepocreadium album* (RUSSELL-PINTO *et al.*, 2006; SOARES, 2015). Parasites can be indicators of population structure, which is particularly valuable for commercial exploited fish species, such as horse mackerel and mackerel, and digeneans do play a role in identifying fish populations and elucidating aspects of the fish host biology (MACKENZIE *et al.*, 2008; OLIVA *et al.*, 2008). They can also reveal trophic interactions, and in this respect, digeneans are particularly suitable, as they have complex life cycles involving different intermediate and definitive

hosts (MARCOGLIESE, 2002, 2005). Furthermore, to better understand food web dynamics and ecosystem health, the study of transmission patterns of digeneans is crucial (MACKENZIE *et al.*, 1995; MARCOGLIESE, 2005). The digenean taxa found in sandy and near shore habitats are ideal candidates to understand the effects of environmental changes, and the health of the ecosystems, as well as to study the implications of parasitism in the behaviour of infected hosts. The pathological effect of digeneans in their hosts, was not yet studied in much detail, and could provide a further field of research. Finally, it is important to have a baseline of the occurrence of digeneans, in our changing world, in the light of recent reports on climate changes and biological invasive species (PALM, 2011; POULIN *et al.*, 2011; DUNN & HATCHER, 2015; GOEDKNEGT *et al.*, 2015). The great diversity of digeneans in Portuguese marine waters, further characterizes its connectivity between the North Atlantic temperate waters (e.g. *Cryptocotyle lingua*, *Himasthla elongata*, *Hemiurus appendiculatus*, *Lecithochirium furcolabiatum*) the Mediterranean Sea (*Cainocreadium labracis*, *Schikhobalotrema longivesiculatum*, *Lepocreadium album*) and the South Atlantic (*Prodistomum orientale*). *Renicola roscovita*, *Monascus filiformis* and *Derogenes varicus* are species with broad distributional range in North and South Atlantic, whereas *Opechona bacillaris*, *Ectenurus virgulus*, and *Copiatestes filiferus*, are examples of cosmopolitan species occurring in the Atlantic and Pacific Oceans. Curiously the Monorchiidae, *Lasitotocus tropicus*, *L. typicum* and the Opecoelidae *Pseudopecoeloides chloroscombri*, which are parasites of the digestive tract of *Trachurus trachurus* and *T. picturatus* in the Western Mediterranean and the Bay of Biscay were not found in Portuguese Atlantic waters (HERMIDA *et al.*, 2015), although these fish species are abundant in Portuguese waters and those digeneans occur within the biogeographic region where Portugal is included (GAEVSKAYA & KOVALEVA, 1980, 1985; BARTOLI *et al.*, 2003; BARTOLI & BRAY, 2004; MACKENZIE *et al.*, 2008). Further parasitological surveys of these carangids along the Portuguese mainland coast, increasing the sampling effort, could reveal infection with more digenean parasites.

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