

40499

by alkauniahbiologi@gmail.com 1

Submission date: 27-Jul-2024 08:31AM (UTC-0400)

Submission ID: 2423167932

File name: 40499-121751-1-RV.pdf (646.58K)

Word count: 4428

Character count: 23758

Management of *Pyrrosia* Mirb. (Polypodiaceae) Fern Specimens in Herbarium Depokensis (UIDEP) Universitas Indonesia, Depok

Mega Atria^{1,2,3}, Ghifari Rahmandika^{1,2}, A. Salamah¹, Saifudin¹, Afiatry Putrika^{1,2,3}

¹Departemen Biologi, Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA), Universitas Indonesia, Depok, Indonesia

²Herbarium Depokensis (UIDEP), Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA), Universitas Indonesia, Depok, Indonesia

³Wildlife Biology and Sustainable Landscape (WILD), Department Biologi, Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA), Universitas Indonesia, Depok, Indonesia

*Corresponding author: mega.atrida@sci.ui.ac.id

Abstrak

Herbarium menyimpan koleksi tanaman yang diawetkan yang digunakan untuk tujuan ilmiah. Penting untuk menyimpan informasi tentang tanaman dalam koleksi herbarium yang valid. Penelitian ini bertujuan untuk membangun koleksi dan database valid *Pyrrosia* yang disimpan di Herbarium Depokensis (UIDEP) melalui pengelolaan herbarium. Proses pengelolaannya meliputi validasi taksonomi, revitalisasi spesimen, dan digitalisasi. Hasil validasi taksonomi menunjukkan terdapat 3 spesies *Pyrrosia* yaitu *P. piloselloides*, *P. lanceolata*, dan *P. longifolia*. Ketiga spesies ini dapat dibedakan berdasarkan sisik rimpang, bentuk lamina, dan letak sorai. Pemeriksaan fisik pada seluruh spesimen menunjukkan beberapa permasalahan antara lain bagian spesimen yang lepas dan kerusakan spesimen akibat serangga. Hampir semua koleksi (49 dari 59 spesimen) tidak mencantumkan lamina subur yang merupakan karakter pengidentifikasi penting pada *Pyrrosia*. Untuk melengkapi data herbarium, dilakukan pengumpulan 10 sampel *Pyrrosia* baru di Ruang Terbuka Hijau (RTHK) Universitas Indonesia. Semua data dan gambar yang valid menjalani proses digitalisasi. Data digital tersebut kemudian diunggah ke website Herbarium UIDEP (ruangkoleksibiotaui.id). Hal ini menghasilkan database *Pyrrosia* yang dapat diakses secara luas oleh masyarakat.

Kata kunci: Digitalisasi; Herbarium UIDEP; Polypodiaceae, *Pyrrosia lanceolata*, *Pyrrosia longifolia*, *Pyrrosia piloselloides*.

Abstract

Herbarium harbour collections of preserved plants used for scientific purposes. It is important to keep informations about plants in a valid herbarium collection. This study aims to establish a valid collection and database of *Pyrrosia* stored in Herbarium Depokensis (UIDEP) through herbarium management. The management process includes taxonomic validation, specimen revitalization, and digitization. Taxonomic validation results showed there were 3 species of *Pyrrosia* namely *P. piloselloides*, *P. lanceolata*, and *P. longifolia*. These three species can be distinguished by rhizome scales, the shape of the lamina, and soral position. Physical examination throughout

37 specimens showed several problems including loose specimen parts and specimen damage due to insects. Almost
38 all collections (49 out of 59 specimens) did not include fertile lamina which is an important identifying character
39 in *Pyrrosia*. To complete the herbarium data, 10 new *Pyrrosia* samples were collected at Green Spaces (RTHK)
40 in Universitas Indonesia. All valid data and pictures undergo digitization process. Those digitized data were then
41 uploaded to the Herbarium UIDEP website (ruangkoleksibiotaui.id). This resulted to a *Pyrrosia* database that can
42 be widely accessed by public.

43 **Keywords:** Digitization; Herbarium UIDEP; Polypodiaceae; *Pyrrosia lanceolata*; *Pyrrosia longifolia*; *Pyrrosia*
44 *piloselloides*.

45 INTRODUCTION

46 Herbarium is a collection of preserved plants stored in a room with specific environmental
47 conditions, such as temperature and humidity. Herbariums are usually managed by scientific
48 institutions that are responsible for storing and administering their use (Bridson &
49 Forman, 1992). The herbarium acts as a repository for reference material, a means for
50 identifying species, source of confirmed taxa names, and a comprehensive data bank. Aside
51 from its traditional role, herbarium nowadays have broader purposes. Digital as well as
52 traditional collections have been used to document plant ecology such as the range of rare
53 species, its declining patterns, or the spread of invasive plants. Ecological botanists compared
54 specimens from different times and places using herbarium collections (López & Sassone, 2019).
55 The herbarium data is digitized to make it more widely accessible. The database could also be
56 sorted in various ways to fulfill many practical needs outside of the traditional alphabetical
57 sorting of the taxa. For example, the available taxa can be sorted according to the area of
58 distribution or its genetic relationship to other taxa, to further understand a certain taxon in both
59 matters. Those data are important as a source of information related to taxonomic information
60 on plant specimens. A researcher can use the herbarium collection stored as a reference to
61 identify other specimens that are not yet recognized or find out the distribution of a taxa by
62 looking at the description of the location of the collection on the label. Therefore, the herbarium
63 is considered an asset and a wealth of knowledge because it stores taxonomic and ecological
64 data as well as representing plant diversity (Besnard et al., 2018).

65 Some local herbarium units are managed by schools or universities to act as a learning
66 facility. One of them is Herbarium Depokensis (UIDEP) in the Department of Biology, Faculty
67 of Mathematics and Natural Sciences Universitas Indonesia. UIDEP stores a collection of
68 herbarium specimens from various locations in Indonesia, but mostly from UI's Green Spaces
69 (RTHK). The specimens are collected from biodiversity exploration conducted by the students,
70 or outcomes from practice classes. At least 400 of the specimens stored in UIDEP are
71 Pteridophytes. One of the notable genera in Pteridophyta is *Pyrrosia*, which was first described
72 by Mirbel (1803) (Hovenkamp & Wessendorp, 1986). *Pyrrosia* generally have thick and fleshy
73 simple leaves. *Pyrrosia* leaves are usually dimorphic (different leaf shape between sterile and
74 fertile leaves) (Sofiyanti et al., 2015). *Pyrrosia* species is used as an ornamental and medicinal
75 plant. Malays and Filipinos used to use *Pyrrosia* leaves as an external medicine. *P. piloselloides*
76 leaf juice is reported to be used by Indonesian people as a cough medicine, constipation, and
77 gonorrhea (Fatimah, 2009; Natalia, 2012).

78 The collection of *Pyrrosia* specimens stored in UIDEP have not been well-curated. The
79 problems regarding the specimens itself were incomplete diagnostic characters of the fern,
80 mainly caused by physical damage while storing or insufficient herbarium preservation method.
81 In addition, there is a large part of the collection with old taxonomic information and has not

been updated. This includes the species name in some of the specimen label being *Drymoglossum* (*Pyrrosia*'s synonym). To maximize its function, herbarium collections must be correctly maintained which can be called Herbarium Management (Harris & Marsico, 2017).

This study focuses on two kinds of work in herbarium. One is about the taxonomy aspect of herbarium collections stored in UIDEP, which includes its accuracy in naming the plant specimen and how well the taxa were grouped according to the latest taxonomy classifications. The other aspect is the technical handling of those herbaria itself. That comprises on how well the specimens were stored in the unit, and also the standard procedure of collecting and arranging a plant on herbarium paper. The objective of this study is to carry out Herbarium Management through a revitalization of all specimens which includes physical condition analysis, evaluation of species naming, and revitalization of each *Pyrrosia* specimens in UIDEP before digitizing the herbarium in an online database for easier access.

1. Materials and methods

The validation and specimen digitization activities were carried out in Herbarium Depokensis (UIDEP), Ruang Koleksi Biota Department of Biology, FMIPA Universitas Indonesia, Depok. The herbarium sheets that will be examined are all specimens named *Pyrrosia* spp. and *Drymoglossum* spp. on its label, a total of 59 specimens labeled as *P. piloselloides*, *P. lanceolata*, *P. longifolia*, *P. nummularifolia*, *D. piloselloides*, *Drymoglossum* sp. and *Pyrrosia* spp. When observing herbarium specimens for species validation, a Nikon Stereo Microscope SMZ745 and an Olympus long-arm microscope were used. A computer device is used to input data from validation stages to the final databasing. When remounting the specimen, sewing thread, paper tape, scissors, glue, stationery, and isolation tape are needed. Revision labels are also used to mark the revised taxa as needed. Finally, specimen documentation for digitization using the Canon EOS 500D DSLR camera that was attached to a Canon Copy Stand.

Herbarium management is carried out in three main revitalization steps (Natural Herbarium of Cultivated Plants, 2019), which include taxonomic nomenclature validation, specimens repairment, and digitizing all specimens (including documentation and databasing). First, all specimens identified as *Pyrrosia* spp. and *Drymoglossum* spp. were re-grouped based on morphological characters' similarities between specimens. The method for morphometry was done through detailed morphological examination. The main characters of each group were compared with references, to confirm that the specimen is actually the species name that is written on the label. In this study, a couple of reference sources were used such as *Pyrrosia* monograph by Hovenkamp (1986), *Flora Malesiana: Ferns and Fern Allies* (1998), and PPG 2016 to validate specimens' nomenclature. Herbarium specimens were compared with each other's characteristics and determined whether or not they belonged to the same taxa group. The validated specimens are then ready for repairment process. Repairment of all specimens has been made for 2 aspects, physical condition of the herbarium sheets and information validation written in the label. Each herbarium sheet is carefully observed, and problems appeared were identified. Both specimens' repairment and specimens' label checking were done based on herbarium references (Christenhusz & Chase, 2014). Digitization was carried out for all valid herbarium data resulted from previous work stages. The process was done in two steps, specimen documentation and data uploading to the website. Pictures were taken for each specimen with a DSLR camera that was mounted on a Copy Stand, the use of a photo lamp as a modification of lighting was made to ensure that the photos look as close as the actual specimen. All valid data in the herbarium label were transferred into an excel spreadsheet. Both the pictures and specimens' data uploaded to Herbarium UIDEP online database (www.ruangkoleksibiotaui.id).

2. Results and discussion

2.1. Nomenclature validation

129 All 59 herbarium sheets named *Pyrrosia* spp. and *Drymoglossum* spp. on its existing label before
 130 the validation process were then confirmed as *Pyrrosia*. The diagnostic character for this genus is the
 131 stellate hairs found on the surface of the lamina. Detailed morphological examination on those
 132 specimens resulted in three taxa of *Pyrrosia* (*P. piloselloides*, *P. lanceolata*, and *P. longifolia*). There
 133 was some nomenclature difference between the existent label and validation results (Table 1), which
 134 then were updated to the latter. Nomenclature changes were made possible by detailed morphological
 135 examination on several key characters of *P. piloselloides*, *P. lanceolata*, and *P. longifolia*, as shown on
 136 Table 2.
 137
 138 **Table 1.** Comparison of *Pyrrosia* species naming in Herbarium UIDEP before and after the validation
 139 process. (Numbers refer as the amount of specimen sheets)

No.	Collection name	Year of collection	Before validation Article Error	After validation	Validation results
1	<i>P. piloselloides</i>	2014 (1), 2017 (5), 2019 (1)	7	51	2 specimens validated to <i>P. longifolia</i>
2	<i>P. lanceolata</i>	2017	2	5	
3	<i>P. longifolia</i>	2014	1	3	
4	<i>P. nummularifolia</i>	2019	2	-	Identified as <i>P.</i> <i>piloselloides</i>
5	<i>Pyrrosia</i> sp.	2017	4	-	2 identified as <i>P.</i> <i>piloselloides</i> and 2 identified as <i>P.</i> <i>lanceolata</i>
6	<i>D. piloselloides</i>	1988 (1), 1989 (1), 2002 (11), 2006 (7), 2007 (12), 2017 (3), 2019 (2), no info (4)	41	-	Moved to <i>P. piloselloides</i> (40 specimens) and <i>P.</i> <i>lanceolata</i> (1 specimen)
7	<i>Drymoglossum</i> sp.	2007	2	-	Identified as <i>P.</i> <i>piloselloides</i>
Total			59		<i>Sp.</i>

Table 2. Diagnostic characters of *Pyrrosia* spp. in Herbarium UIDEP

Diagnostic Character	A (<i>P. piloselloides</i>)	B (<i>P. lanceolata</i>)	C (<i>P. longifolia</i>)
Rhizome	Thickness < 1.5mm (filiform)	1-2mm thick, flexible	1.8-2.7mm thick, rigid
Rhizome scales*	Ciliate, peltate without acumen	Ciliate, peltate with acumen	Entire, peltate with acumen
Distance between phylloids	0.8-1.7 cm	1-2 cm	1.8-2.2 cm
Sterile lamina	Shape: Orbiculate to ellipse	Elliptical, lanceolate to linear	Elliptical to linear
	Apex: Rounded to obtuse	Acute to attenuate	Rounded to acute
	Base: Rounded to obtuse	Attenuate	Rounded to attenuate
	Stalk: Sessile to stalked < 0.7 cm	1-2 cm long	Length 1-3,5 cm

Fertile lamina	Shape	Ellipse to lanceolate	Elliptical to linear	Linear (with length > 20 cm / strap-shaped)
	Sori*	Lengthwise throughout the margin	Rounded, in 2 rows between midrib and margin	Rounded, spreads from the apex to almost the middle of the leaf
	Amount	51 sheets	5 sheets	3 sheets

the sign (*) indicates the micromorphological character observed with the aid of a microscope

Validation of all specimens as *Pyrrosia* was indicated by long-creeping rhizomes, simple leaves, and entire leaf margins. The diagnostic character of the genus *Pyrrosia* found was the presence of stellate hairs on the surface of the lamina. The stellate hairs have acicular rays and were found to be denser on the abaxial part of the leaf than on the adaxial. The presence of stellate hairs distinguishes *Pyrrosia* from other genera of ferns which also have thick leaves and entire leaf margins such as *Lemmaphyllum* (Donk, 1954).

To validate the species name within *Pyrrosia* diagnostics that were used including macromorphological and micromorphological characters. The macromorphological characters observed were rhizome shape and size, distance between phylloids, and leaf shape (including apex, base, and stalk). In general, the two species can be distinguished by apex and/or basal of the sterile lamina. In *P. lanceolata* the apex and/or basal part is more tapered and the widest part of the lamina is at the bottom or top of the middle of the leaf (lanceolate). In contrast, *P. piloselloides* has an overall elliptical leaf shape. *P. longifolia* has a leaf shape that is quite different from the other two species because of its strap-shaped leaf. The length of the leaves of *P. longifolia* can reach 20 cm or more (in specimens, the longest found is 54 cm).

Micromorphological diagnostic characters used to distinguish the three groups of *Pyrrosia* specimen collections in Herbarium UIDEP were rhizome scales and sori. Rhizome scales are found along the surface of the rhizome to the phyllopod of the *Pyrrosia*. The results of rhizome scales observation with a microscope showed that there were variations in the shape of the scales between species (Figure 1). All of the rhizome scales observed in the *Pyrrosia* specimens had the same attachment, which is peltate (attached to the center of the scales). Peltate forms and attachments in *Pyrrosia* were also described in Flora Malesiana ser. II Vol. 3[12]

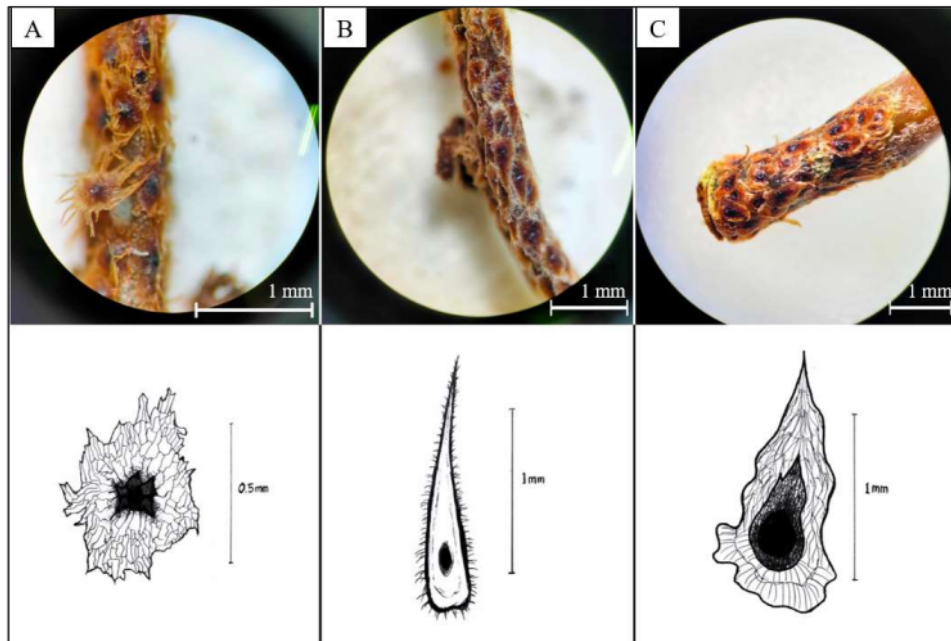


Figure 1. Rhizome scales on *Pyrrosia piloselloides* (A), *Pyrrosia lanceolata* (B), and *Pyrrosia longifolia* (C).

Based on Figure 1, the differences between species were indicated by the shape of the scales and the presence/absence of cilia at the margins of the scales. The shape of the rhizome scales in Figure (A) was found in the *P. piloselloides* specimens. The margin of the rhizome scales was ciliate and do not have a long acumen (pointed angle). The size of the scales is also the smallest compared to the other two groups, namely ± 1 mm long and 0.8 mm wide. In *P. lanceolata*, peltate scales were found (Fig. 1B). The margins of the scales were also ciliate but there is an acumen structure that looks elongated. The length of the scales of *P. lanceolata* can reach 1.5 to 3 mm while the width is 0.3-1.2 mm. The scale form (C) was found in the *P. longifolia*. Form C looks most distinctly different because the scale margins were flat without cilia (entire) and also have acumen. The size of the scales observed in *P. longifolia* specimen was $\pm 1-3.2 \times 0.6-1.5$ mm. This is consistent with the descriptions in the monographs of *Pyrrosia* [4] and Flora Malesiana ser. II Vol. 3 [12] so that it can be used as a diagnostic character to distinguish species.

In addition to rhizome scales, another micromorphological character observed to distinguish *Pyrrosia* species in Herbarium DEP was its sori arrangement. The position of the sori on the fertile lamina was observed as shown in Figure 2. Sori in Figure (A) was found in the *P. piloselloides*, it could be seen that the sori were arranged longitudinally at the margin. The sori arrangement in figure (B) was found in *P. lanceolata*. Sori rounded, arranged in 2 rows on the abaxial surface of the leaf lamina between the midrib and margin. Sori looks a bit sunken and covered in thick stellate hairs. Sori in Figure (C) was found in the *P. longifolia*. Sori rounded and scattered on the abaxial surface of the lamina, but only found around the apex to before the middle of the leaf. No sori were found around the leaf basal area even on very long (> 50 cm) lamina.

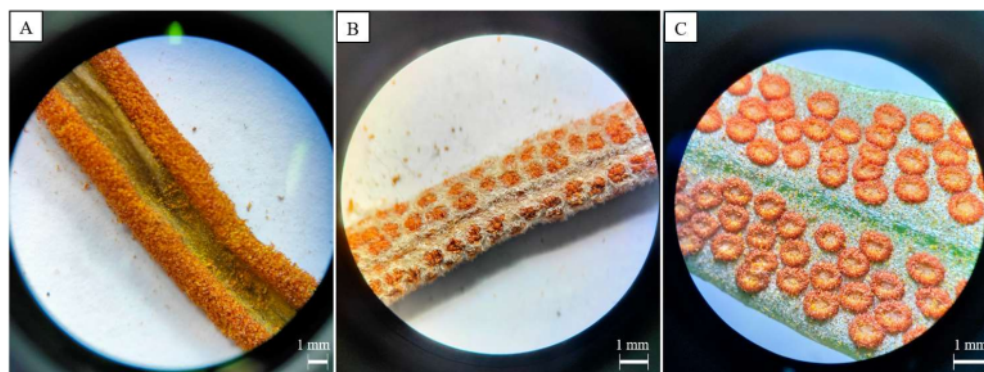


Figure 2. Soral arrangement on the fertile lamina of *Pyrrosia piloselloides* (A), *Pyrrosia lanceolata* (B), and *Pyrrosia longifolia* (C)

2.2. Physical examination and specimen handling

Herbarium sheets examination of all specimens identified types of damage and inaccurate information in the labels as shown on Table 3.

Table 3. Problems regarding the physical condition of the herbarium and repairment efforts

Specimen Problems/Damages	Affected Sheets	Repairment Efforts
Sample detached from duplex	5	Re-arranged and re-mounted with isolation tape
No fertile lamina	44	Stored in herbarium, added re-collection the same species plants with complete identification characters
Damages to the fertile lamina	5	
Incorrect nomenclature	51	Added a revision label above the herbarium label with the correct name
Incomplete label notes	5	Added notes from field observations
Insects found on the specimen	2	Disinfected at 40° C oven for 1-2 days, cleaned the storage rack

Most of the problems occurred on the plant specimen itself, whether it is from physical damage or not enough representation of preserved plant parts on the herbarium sheet. Damages found including the crumbled lamina, decays caused by insects, etc. These problems were resolved by removing the damaged part but still paying attention to its representative plant parts so it stays complete and not reducing any information on herbarium specimens. The other problem is incomplete herbarium in *Pyrrosia* specimens, mainly lack of fertile lamina of the fern. For that case, additional notes regarding the morphological features of the plant were added. The date was taken from observations throughout the nomenclature validation process, so that the future user will be informed about the specimen's characteristics, especially if its nomenclature were updated. New *Pyrrosia* samples were also collected to make a voucher herbarium and completing the data of existing specimens without the fertile lamina.

Poor mounting is solved by rearrangement of the specimen on the duplex paper. Existing herbarium specimens that have damage on the plant parts can be repaired with the same equipment as the general mounting process in making the herbarium. Specimens were arranged above the duplex paper and remounted if the old glue/tape has loosened and/or the specimen position is disorganized.

A good herbarium relies on the complete and accurate information stated in its label. The label should have information on the specimen's scientific name, vernacular name, date, and location of collection, collector's name, and habitat/ecological data. It should also include supplementary data such

as notes on colours, plant habit, and other features that may be important for identification but cannot be shown well as a preserved specimen [13]. Identification errors or nomenclature updates on the labels were corrected by adding revision labels. The label contains the correct nomenclature/taxa description and is mounted to the top of the existing herbarium label.

To maintain the specimens' physical condition after revitalization, a standard procedure of all herbarium works was established. This includes standard storing temperature and humidity, regular examination for pests or other potential problems, and new specimen guideline for future collections. The references used during taxonomic validation were also used to determine what plant parts need to be present on a *Pyrrosia* herbarium specimen. Collecting ferns for a herbarium is not just about taking the plant and preserving it, but planning ahead so the information within can be observed and studied even after a long time. When collecting and preserving the plant for herbarium making, it is important to include some of the key characters to identify the plant. So that the plants' morphological characteristics could be representatively displayed on a herbarium sheet.

Based on those physical examination results, we advise some specific techniques in handling *Pyrrosia* specimens. First, make sure to take complete note of the fern habit before collecting. *Pyrrosia* species characteristics varied in many things, some are no longer visible after preserving, it is best to write them down first. Lastly, make sure to collect all parts of *Pyrrosia* that is crucial for identification such as rhizome and fertile lamina.

2.3. Digitization of the specimen

The valid herbaria resulted from the revitalization process (both specimen and label) is documented to an online database [13]. All specimen sheets were digitally documented and resulted in representative herbarium photos and a massive database containing complete information of all *Pyrrosia* collection. The specimens itself were photographed with a DSLR camera that was mounted on a Copy Stand. In order to make the photos look as close as possible to the original specimen, a lamp is used to provide proper lighting and a white photo box to spread the light evenly throughout the specimen. In the documentation process, herbarium sheets were placed in the photo box on the stage board of the Copy Stand to be photographed one by one into a jpeg file format. Data on the label is also typed in Herbarium UIDEP database spreadsheet.

The data regarding specimen identity, location, and taxonomy information were then uploaded to the Herbarium UIDEP website. It could be accessed on www.ruangkoleksibiotaui.id. Additional pictures were provided to give more information about the said specimen for the viewers. After the herbarium data is entered on the input page, the specimen information cannot be directly visible publicly on the website. However, the uploaded data is entered in the admin menu for approval (Figure 3). The approval process by the admin is needed to protect the database from arbitrary specimen uploads. After the herbarium data entry is approved, the input results will appear publicly and can be accessed by entering the appropriate keywords on the search page (Figure 4). An herbarium data can be searched by family name, genus, species, and local name.

No	Specimen ID	Nama MHS	NPM	Coll. No.	Collector	Collection Date	Location	Family	Genus
1	0	Ghifari Rahmandika	1606826905	M 125	M. Muhaimin	11 January 14	UI-Depok	Polypodiaceae	Pyrrosia

Figure 3. The input results shown on the website admin menu [Source: ruangkoleksibiotaui.id]

Welcome to the Ruang Koleksi Biota
Departemen Biologi FMIPA UI Botany
Catalogue

Simple searches can be initiated from this page. Please refer to the help pages for advice
as to how to formulate database queries. Please contact us if you have ideas as to how we
can improve this site.

Search

Search here..

Search by:

Family	Genus	Species	Local Name	Quick Search Name
--------	-------	---------	------------	-------------------

Submit

Figure 4. Database search page on the Herbarium UIDEP website page [Source: ruangkoleksibiotaui.id]

3. Conclusion

The management has been carried out to the herbarium specimens which has resulted in 3 validated species of *Pyrrosia* in Herbarium Depokensis (UIDEP) collection, namely *Pyrrosia piloselloides*, *Pyrrosia lanceolata*, and *Pyrrosia longifolia*. The three species can be distinguished by the morphology of the rhizome, lamina, and soral position. Nomenclature validation and specimen revitalization resulted in a collection of valid *Pyrrosia* specimens. Digitization of valid *Pyrrosia* specimen collection produced an online database that can be accessed and used by the public.

Acknowledgments

We would like to thank Universitas Indonesia for funding this research through Publikasi Terindeks Internasional (PUTI) Grant 2020 with contract number NKB-946/UN2.RST/HKP.05.00/2020. Many thanks to RKB UI specimen curator Alexander Tianara for the guidance while working in Herbarium UIDEP. We also thank fellow research students Muhaimin and Rahayu Adinda Putri for giving us great help during this research.

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