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Computerization of KFRI Herbarium- Phase II

(Final Technical Report of the Project KFRI 574/09)

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Summary

Computerisation or digitisation of herbarium material is a process of capturing data and images and storing them in digital form. This is also known as '*Virtual Herbarium*' which helps to improve the longevity and availability of specimens to a wider audience. KFRI herbarium was recognized in 1982 by the International Association of Plant Taxonomists (IAPT), and is known by the acronym KFRI in Index Herbariorum. The herbarium holds over 10306 specimens representing more than 2040 species belonging to 203 families. For the easy instant access of specimens from any part of the world, entire herbarium specimens of KFRI herbarium were digitized. This can be accessed by botanists and other researchers free of charge through the data portal at http://kfriherbarium.org/. The website provides basic and advanced search capabilities. Default search can be conducted in all fields of the herbarium database, while advanced search allows searches in specific fields like genus, species, local names etc., KFRI online herbarium is a gesture of sharing information accumulated by the researchers who had contributed to build the herbarium painstakingly with the academic community and general public.

സംഗ്രഹം

കേരള വനഗവേഷണകേന്ദ്രത്തിൽ 1982 ലാണ് "ഉണക്കി പ്രത്യേകയിനം കടലാസുകളിൽ ഒട്ടിച്ചെടുത്ത് വിവരങ്ങൾ ഉൾപ്പെടുത്തിയ സസ്യശേഖരം" അഥവ 'ഹെർബേറിയം' തയ്യാറാക്കപ്പെട്ടിട്ടുള്ളത്. 203 സസ്യകുടുംബങ്ങളിലായി 2040 ഇനങ്ങളുടെ 10306 ലധികം സസ്യങ്ങൾ ഈ ശേഖരത്തിലുണ്ട്. ഈ ശേഖരം ഗവേഷണവിദ്യാത്ഥികൾ, ശാസ്ത്രജ്ഞർ, വനപരിപാലകർ തുടങ്ങിയവർക്ക് നിരന്തരപഠനത്തിന് സഹായകരമാണ്. ലോകത്ത് എവിടെ നിന്നും ഈ ശേഖരം ഉപയോഗിക്കാനുള്ള സൗകര്യാർത്ഥം കെ.എഫ്.ആർ.ഐ ഹെർബേറിയം കമ്പ്യൂട്ടർവത്ക്കരിക്കുകയുണ്ടായി. http://kfriherbarium.org എന്ന വെബ് പോർട്ടലിലൂടെ ഹെർബേറിയം ഉപയോഗപ്പെടുത്താം. സസ്യങ്ങളുടെ വിവിധ ജനുസ്സുകൾ,വിവരണങ്ങൾ,അവ കാണപ്പെടുന്ന വിവിധതരം വനങ്ങൾ, സമുദ്രനിരപ്പിൽ നിന്നുമുള്ള ഉയരം,സസ്യങ്ങൾ ശേഖരിച്ച സ്ഥലങ്ങൾ, വ്യക്തികൾ എന്നിവ ഈ വെബ് പോർട്ടലിലൂടെ ലഭ്യമാകുന്നതാണ് .

Introduction

A herbarium (plural: *herbaria)* once, called dry gardens, are collections of dried plant specimens, catalogued, and arranged systematically for research on taxonomy, systematics and conservation. They form prime resources for identification of specimens and provide a reference point for clarifying how plant names should be applied. Hence, herbaria are of value because they contain many bits of information in a historical sense - plants collected at a particular location at a particular time.

Importance of the Herbarium

Herbaria provide the comparative material that is essential for studies on various disciplines of botany like plant systematics, morphology, biodiversity, ethnobotany, ecology, conservation biology, anatomy, paleobiology etc., The herbarium specimens are now widely used for comparing phenological studies, developing species distribution models through ecological niche modeling, documenting the spread of invasive weeds and as voucher specimens for DNA barcoding. To track historical record of change of vegetation over time, the specimens preserved in a herbarium is worthy. For examples Ronald Stuckey was a pioneer man who made 11 historical reconstructions of exotic plant spread from 1966 to 1985 (Stuckey, 1966). Lavoie and Saint-Louis (2008) and Dolan *et al.*, (2011) used herbarium specimens to document the impact of exotic species on the floristic composition of urban or natural areas. Similarly, herbarium specimens have been used to study pollution caused by carbon dioxide (Woodward, 1987; Miller-Rushing *et al.*, 2009; Bonal *et al.*, 2011), hydrocarbons (Foan *et al.*, 2010), heavy metals (Lee and Tallis, 1973; Herpin *et al.*, 1997; Penuelas and Filella, 2002), nitrogen (Pitcairn and Fowler, 1995; Solga *et al.*, 2006; Wilson *et al.*, 2009), and phosphorus (Penuelas and Filella, 2001). Primack *et al.*, (2004) reported the relevance of herbarium specimens for reconstructing phenological changes associated with climate warming. New techniques for studying herbarium specimens have been developed in the fields of chemical ecology (Zangerl and Berenbaum, 2005; Cook *et al.*, 2009), pollination ecology (Ollerton *et al.*, 2009; Pauw and Hawkins, 2011) and insect outbreaks (Lees *et al.*, 2011). With the expansion of molecular techniques, DNA isolation from herbarium specimens were standardized (Rogers and Bendich; 1994; Ribeiro Lovato, 2007) and DNA from

herbarium specimens have been satisfactorily obtained from vascular plants about 200 years old.

History of Herbarium

The first herbarium was established in Kassel, Germany in 1569. Currently there are 3400 herbaria in 180 countries containing approximately 350,000,000 specimens that document the earth's vegetation for the past 400 years. The first reference collection of dried plants was that of Thomas of Sarepba (1297-c.1378) and is in a book form, pressed and dried plants or plant parts being glued onto blank pages. The earliest known herbaria of this kind were made at the Universities of Bologna (1570), Basel (1588), Oxford (1621) and at the *Naturkundemuseum* in Kassel (Natural History Museum in Ottoneum), Germany (1569). The earliest herbaria were formed in Italy in the 16th century, pressed plants mounted on sheets of paper bound into books which become standard practice until the 18th century. The herbarium of Sir Hans Sloane (1660–1753) is a typical example. This collection is housed at the Natural History Museum in London, comprises 260 bound volumes, made up of specimens received from many collectors. It has been estimated that the world's 2721 active herbaria together house c. 361 million specimens (Holmgren *et al.,* 1990) which cover most of the world's plant species, including many narrowly restricted local endemics, species remaining to be described (Bebber *et al.*, 2010; Joppa *et al.*, 2011), and those already extinct.

The need for herbarium digitization

Digital Taxonomy (http://digitaltaxonomy.infobio.net/) was born in January 1998, as an attempt to present a wide-ranging resource of information on software, methodologies, standards, data sources, and promote open source and free software tools for biodiversity informatics. For taxonomic revisions and phylogenetic studies the consultation of both national and international herbaria for comparison of specimens especially type specimens, old collections are inevitable. One of the major advantages of digitized specimens is that the information on them can be accessed without damage to the originals. During the computer revolution and development of imaging technologies, just as libraries have been at the forefront of digitizing information about their books, the same thing is true of herbaria. The international funding agencies like National Science

Foundation (NSF) supported funding for digitizing efforts so all the major herbaria have their collections online (iDigBio, 2013). The Global Biodiversity Information Facility (GBIF) has a portal hosting about 400 million records about species of all kinds are available electronically (GBIF, 2013). The digitized specimens are of high quality and can be magnified, so researchers can inspect texture and fine structures. It is also valuable for them to compare specimens with photographs of the same plant, and with illustrations.

Virtual Herbarium

The term "Virtual Herbarium" refers to a herbarium which has its entire collection in digital, indexed form integrated with other digital resources such as the world wide web, online biodiversity databases and search engines (Guala, 2000). This cannot replace the importance of a physical herbarium collection; however, it raises the value of the collection greatly in terms of the economic benefits to the institution, logistics, increased efficiency and most importantly, posterity (Guala, 2000; Thiers, 2002; Thacker, 2003). A virtual herbarium is a web-based collection of digital images of preserved plants or its parts. It is accompanied by all information of data sheet including botanical name, family, Date of collection, Distribution details, specimen details, and in some cases maps are also included in the virtual herbarium. The examples are Austriala's Virtual Herbarium, The C.V. Starr Virtual Herbarium, Utah Valley State College Virtual Herbarium, University of Connecticut Virtual Herbarium etc.,

The major internationally known digitized plant collections available online are Herbarium Catalogue of the Royal Botanic Gardens (RGB) at Kew (http://apps.kew.org/herbcat/navigator. do); Tropicos, the interactive database of Missourie Botanical Garden (http://www.tropicos.org/); C. V. Star Virtual Herbarium from New York Botanical Garden's International Plant Science Centre (http://sciweb.nybg.org/science2/VirtualHerbarium.asp); BGCI – Botanic Gardens Conservation International with several centres (http://www.bgci.org/); Herbarium Berolinense of Botanical Garden and Botanical Museum (BGBM) at Berlin – Dahlem

(http://ww2.bgbm.org/Herbarium/default.cfm), and Plant Database, Northern Ontario, Canada (http://www. northernontarioflora.ca/). In India, only few herbaria have attempted to digitize their specimens and some of them are LWG –Virtual herbarium of the National Botanical Research Institute, Lucknow (http://www.nbri.res.in/herbarium/), Regional Plant Resource Centre (RPRC digital herbarium), Odisha (http://www.rprcbbsr.com/herbarium/), Janaki Ammal Herbarium (formerly RRL, Jammu; http://www.iiim.res.in/herbarium/herbarium.htm), National Institute of Oceanography (NIO) – Digital Herbarium (www.nio.org). Herbarium JCB, Centre for Ecological Sciences, Indian Institute of Science, Bangalore. Various virtual herbaria catalogue and access details are provided in Table 1.

Table 1. List of various virtual herbaria all over the world with web details

Sl. No	Name of Herbaria	Web Address
1	Australia's Virtual Herbarium (AVH)	http://avh.chah.org.au/
2	Royal Botanic Garden Edinburgh - Herbarium Catalogue	http://elmer.rbge.org.uk/bgbase/vherb/bgbasevherb.php
3	Kew Herbarium Catalogue - Royal Botanic Gardens, Kew (K)	http://apps.kew.org/herbcat/navigator.do
4	Home - Virtual Herbarium - Charles Sturt University	http://www.csu.edu.au/herbarium
5	Herbarium–WU; Institute of Botany, University of Vienna	http://herbarium.univie.ac.at/index.htm
6	New Zealand Virtual Herbarium	http://www.virtualherbarium.org.nz
7	UK Overseas Territories (UKOTs) Herbarium	http://herbaria.plants.ox.ac.uk/bol/ukot
8	University Herbarium (UC), Jepson Herbarium (JEPS).	http://ucjeps.berkeley.edu/online_resources.html
9	Neotropical Herbarium Specimens - The Field Museum	http://fm1.fieldmuseum.org/vrrc/
10	The Linnaean Herbarium - The Linnean Society of London	http://linnean-online.org/linnaean_herbarium.html
11	UVU Virtual Herbarium - Utah Valley	http://herbarium.uvu.edu/virtual/
12	Geneva Herbaria Catalogue - Ville de Genève	http://www.ville-ge.ch/musinfo/bd/cjb/chg/?lang=en
13	National Herbarium of the Netherlands (NHN)	http://vstbol.leidenuniv.nl/
14	Botanische Staatssammlung München (M) herbarium; Germany	http://www.botanischestaatssammlung.de/general/herbarium.html
15	Missouri Botanical Garden's	http://www.missouribotanicalgarden.org/plant-

	Herbarium	science/plant-science/resources/herbarium.aspx
16	Smithsonian Tropical Research Institute's Herbarium (SCZ)	http://biogeodb.stri.si.edu/herbarium/
17	Hornsby Herbarium, Australia	http://www.photosau.com/hornsbyherbarium/scripts/home.asp
18	Natural History Museum; UK	http://www.nhm.ac.uk/research-curation/collections/search/index.jsp?mode=collections
19	Herbarium Berolinense; Berlin	http://ww2.bgbm.org/herbarium/
20	Botanische Staatssammlung München (M) Herbarium; Germany, Munich	http://plants.jstor.org/search?t=6451
21	The Herbarium Hamburgense (HBG); Germany	www.herbariumhamburgense.de/

Herbarium data bases

Exclusive herbarium data base management systems are now available to build own herbarium data base. Among these some the important ones are – Bib master, BRAHMS, Herber, Pandora, Systax, Tracy, etc. Selection of appropriate database software for particular herbarium is a crucial one and this depends on the nature of data, size of data and available infrastructure facilities. Some of these software with web address are provided in Table 2

Table 2. List of various herbarium databases and its web address

Sl. No	Name of database	Web Address
1	SMASCH - Jepson and University Herbaria UC Berkeley	http://www.mip.berkeley.edu/www_apps/smasch/
2	BRAHMS	http://herbaria.plants.ox.ac.uk/bol/brahms/Software/v8
3	KE Emu	http://www.kesoftware.com/
4	BG-Base	http://www.bg-base.com/
5	BIOTA	http://viceroy.eeb.uconn.edu/Biota/
6	VAST / TROPICOS	http://www.tropicos.org/
7	Plabel & derivatives FLAS	http://www.flmnh.ufl.edu/herbarium/herbdatabases.htm
8	Alice	http://www.alicesoftware.com/
9	TAXIS- Taxonomic Information System	http://earthcape.com/
10	BIOTICA	http://www.conabio.gob.mx/
11	BibMaster	http://www.gbif.es/bibmaster/bibmaster_in.php
12	HERBAR (MSAccess based)	http://www.gbif.es/herbar/herbar_in.php
13	PANDORA	http://www.ibiblio.org/pub/academic/biology/

		ecology+evolution/software/pandora/
14	SysTax	http://www.biologie.uni-ulm.de/systax/index.html
15	TRACY	http://botany.csdl.tamu.edu/FLORA/input/inputsys.html

KFRI herbarium

The KFRI herbarium was established in 1982 as a part of a research project by N. Sasidharan and V. P. K. Nambiar with 6000 specimens (Sasidharan and Nambiar, 1991). It is recognized by the International Association of Plant Taxonomists (IAPT), and is known by the acronym KFRI by Index Herbariorum (Taxon 37: 503. 1988). Now the herbarium holds over 10306 specimens representing more than 2040 species from 203 families. It holds wide collection of medicinal plants in South India and a pan Indian collection of rattans, palms and bamboos of India including Andaman and Nicobar Islands. The species in the herbaria are indexed in alphabetical order with collection numbers under respective plant families and Bentham and Hooker's system of classification (1867-1883) has been followed for the systematic arrangements of angiosperms. The predominant plant families in the collection are Poaceae (171 spp.), Orchidaceae (151 spp.), Arecaceae (109 spp.), Fabaceae (81 spp.), Euphorbiaceae (96 spp.), Rubiaceae (90 spp.) etc., The herbarium also represented with more than 90 species of pteridophytes. Various research projects on regional floristic and ecological studies, taxonomic revisions which were undertaken during 1985-2012 has made it possible to improve the quality of the herbarium and now it is an active collection in continuous growth.

The preliminary objective of storing and providing access to digital images of KFRI herbarium collection is to facilitate access to the collection. Storing high quality images also has potential to aid long-term preservation of the collection, by reducing the demand of direct handling. Kerala Forest Research Institute Herbarium online resource provides free and immediate access to various collections of digitized plant specimens and associated data for the biodiversity studies.

The purpose of KFRI virtual herbarium project is to efficiently and reliably create and develop an integrated electronic database of collections and make it accessible to the world through a single portal. The main advantage of virtual herbarium is it allows for

much greater and faster access to collection data used in worldwide research. The summary of some major stakeholder benefits with the Virtual Herbarium is provided in Table 3.

Table 3: Summary of some major stakeholder benefits with the Virtual Herbarium.

Possible virtual herbarium stakeholders groups	**Possible benefits of the virtual herbarium project to the major stakeholders**
✓ Scientific community ✓ Biodiversity networks ✓ Botanic gardens ✓ NGO's –Conservation groups ✓ Agriculture and Forest departments ✓ Universities/Colleges/Schools ✓ State Biodiversity Authority ✓ Horticultural industry ✓ Ecotourism industry, Environmental consultants	✓ Identification and analysis of type specimens for conservation, medicine, agriculture and horticulture ✓ Distribution mapping of RET plants ✓ Better understanding of biodiversity of a particular area/ Heritage sites/Regional floras ✓ Selection of conservation reserves ✓ Impact of development projects ✓ Early identification of weed invasion ✓ Bio-prospecting and commercial utilization of native flora, food and natural products.

Our major goal was to digitize all specimens found in KFRI herbaria and to make it accessible to botanists and other researchers free of charge.

Objectives:

- To computerise the herbarium
- To develop search facility so that data and images can be easily retrieved
- To facilitate identification through web based interactive multi-access keys

Materials and Methods

Preparation of a data base:

A data base was prepared including all the information presented on the herbarium specimen label, including species name, author citation, sub-species if any, variety if any, family, subfamily, collection number, locations, date of collection, habitat and the collector's name. Nomenclature status of the specimens was updated using 'The Plant List' (http://www.theplantlist.org/) and DVD version of flowering plants of Kerala (Sasidharan, 2011). All the herbarium specimens were photographed using Canon 9 Camera fixed on a permanent stand and high resolution images were prepared. All the images were edited and a standard scale is provided.

Web Design

The website was developed using standard open-source software on the Linux operating system, including Apache, a web server (http://www.apache.org/); MySQL, a database system (http://www.mysql.com/), and PHP, a scripting language (http://www.php.net/). Plant taxonomic data are stored in the data base, which allows rapid indexed searches to be carried out and the content to be generated dynamically. Binary (non-text) content such as high quality digital image files and documents requiring considerable storage are stored on the file system instead of inside the data base, for greater efficiency. The program is written in PHP. It is a web work which abides MYSQL data base.

Website user interface

An image gallery is provided that allows species to be identified by browsing images. Each image is hyperlinked to the corresponding species webpage. Alphabetically sorted species and family lists allow users to browse by species name and family respectively. The website provides basic and advanced search capabilities. Text entered in basic search is searched in all fields of the herbarium database, while advanced search allows text to be searched in one or more fields (for example, genus, threat status or common name). A comment widget allows users to report corrections or provide any feedback.

Results and Discussion

The data base includes a total of 5297 records representing 203 families. The predominant plant families with maximum records represented are Arecaceae (837 records), Poaceae (381), Orchidaceae (347), Fabaceae (270), Euphorbiaceae (239), Rubiaceae (217) etc., The website provides basic and advanced search capabilities. Default search is conducted in all fields of the herbarium database, while advanced search allows searches in specific fields like genus, species, local names, etc. Queries can be built on multiple keys also such as "riverside flower yellow". The interface is handling Unicode Malayalam for search using vernacular names of plants and location. This "digital herbarium" representing forest flora will be highly useful to Forest Departments, Kerala State Biodiversity Board, Universities, Research Institutions, students and teachers especially for identifying specimens, understanding local names, distribution and phenological details etc. KFRI herbarium data can be accessed through the data portal at http://kfriherbarium.org/

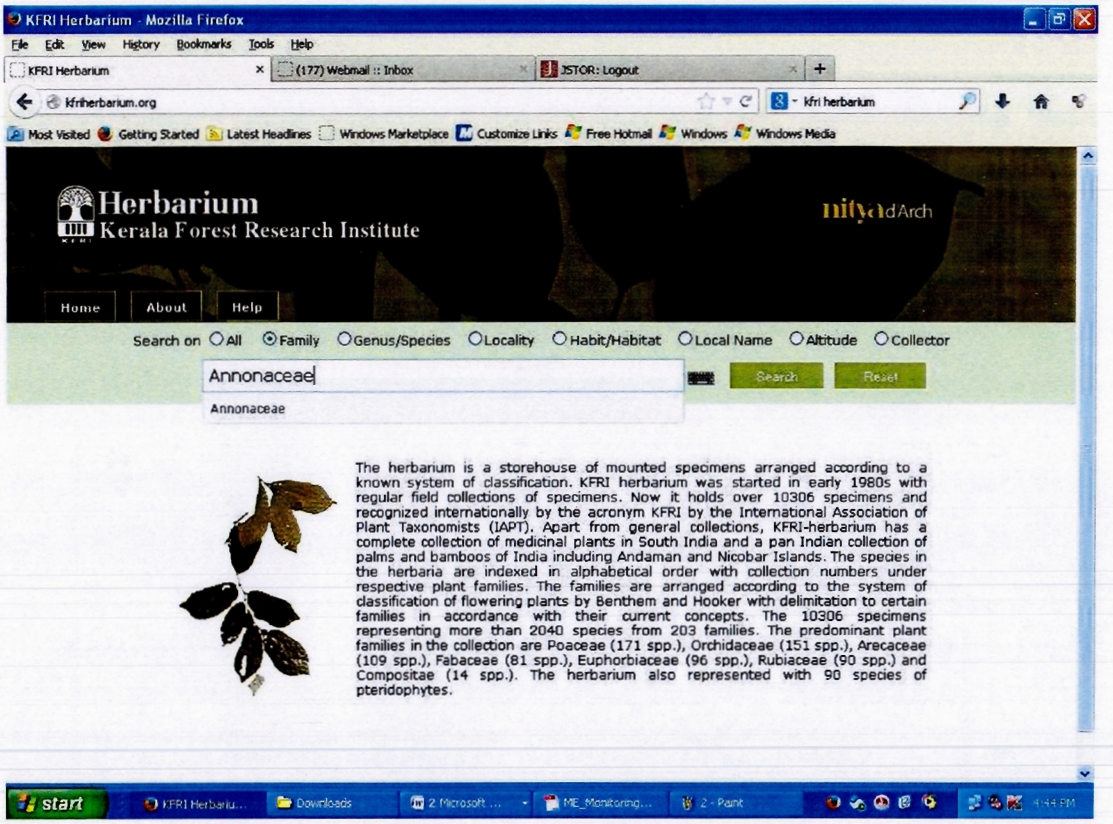
Searching from the Home Page

To search the KFRI Herbarium Catalogue you can enter text into the text box provided on the Home Page. You can choose to search for this text string in the fields of all (searching multiple parameters), Family, Scientific Name (Genus and/or Species), locality, Habit/Habitat, Local name, Altitude and Collector.

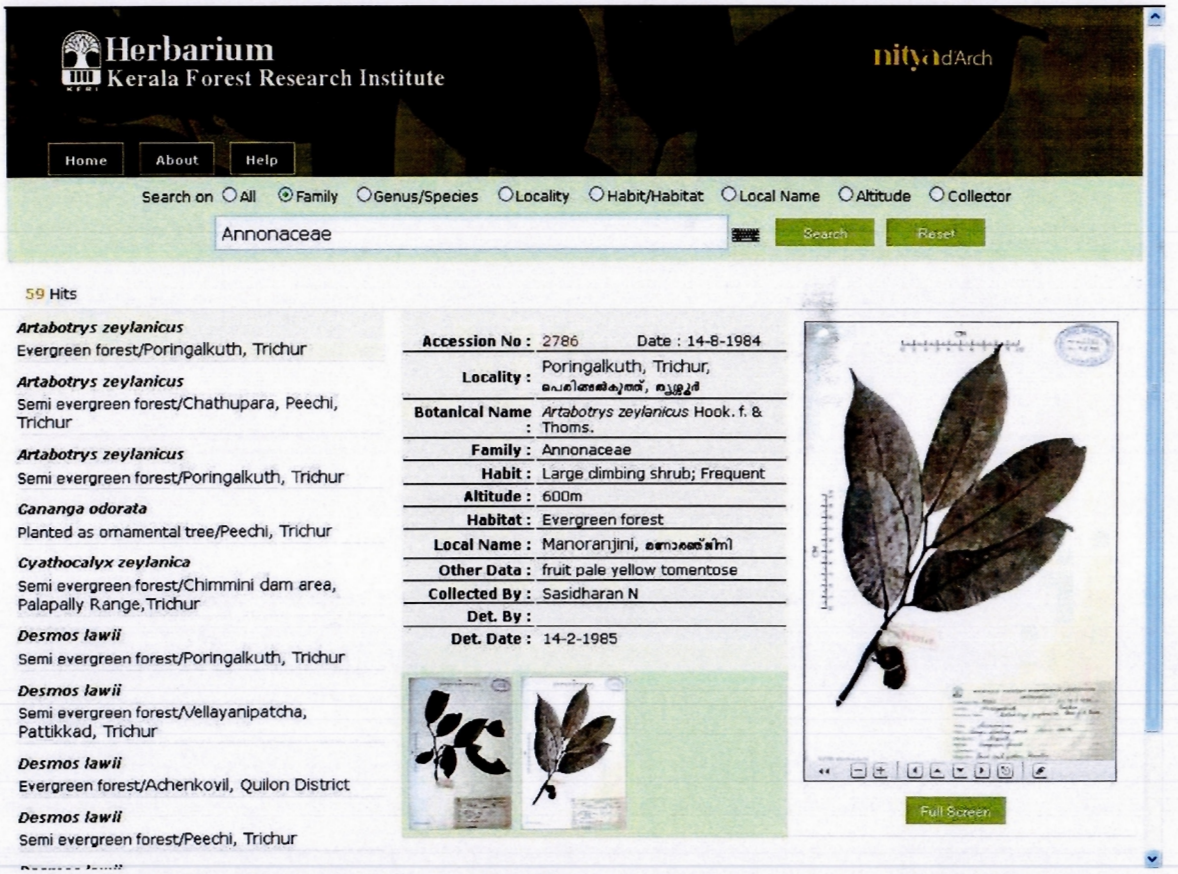
Details of search fields:

- Family
- Scientific Name (Genus and/or Species)
- Locality
- Habit/Habitat
- Local name
- Altitude and collector
- Multiple categories

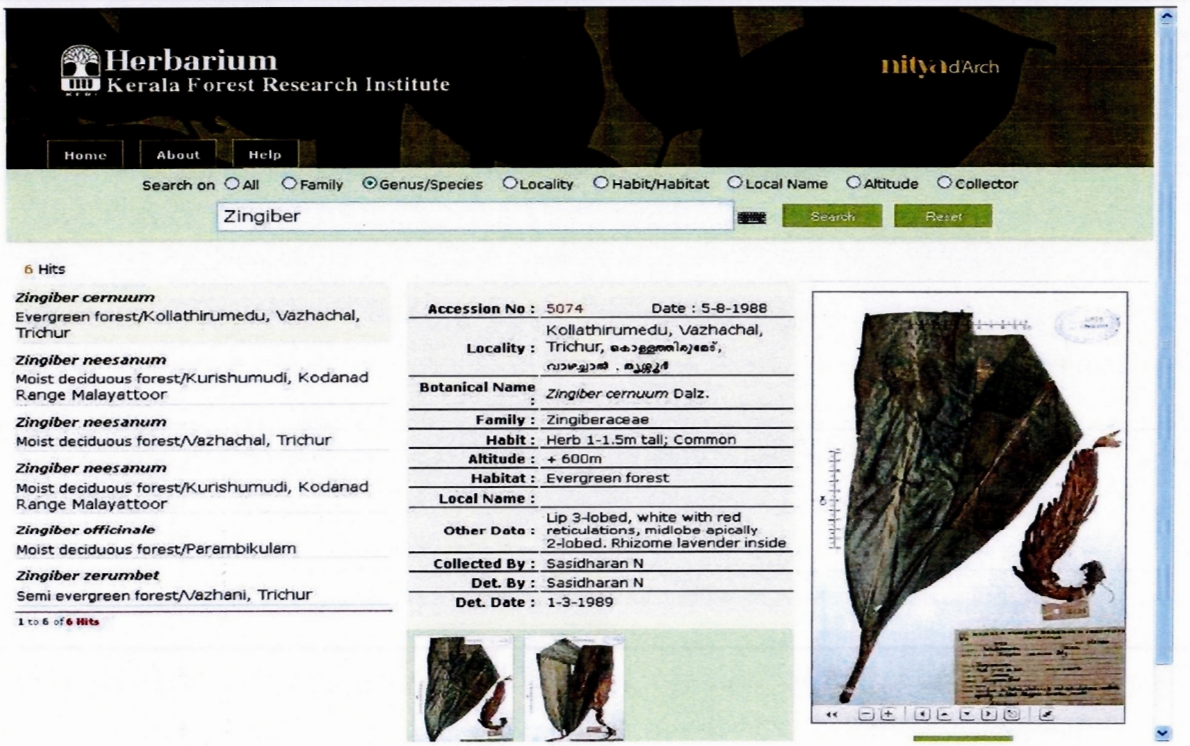
For searching a family



For searching plants in a particular family, need to enter name of that family in text box option; then a window displaying entire species list of members of that family will appeared. Under species list in the middle column details of particular species like Accession No, Date of collection, Botanical name, Habit, Altitude, Habitat, Local name, Other details, name of collector, Determinavit with available thumbnails will be appeared. Search in family wise will enable to monitor rich/poor representatives of collection.

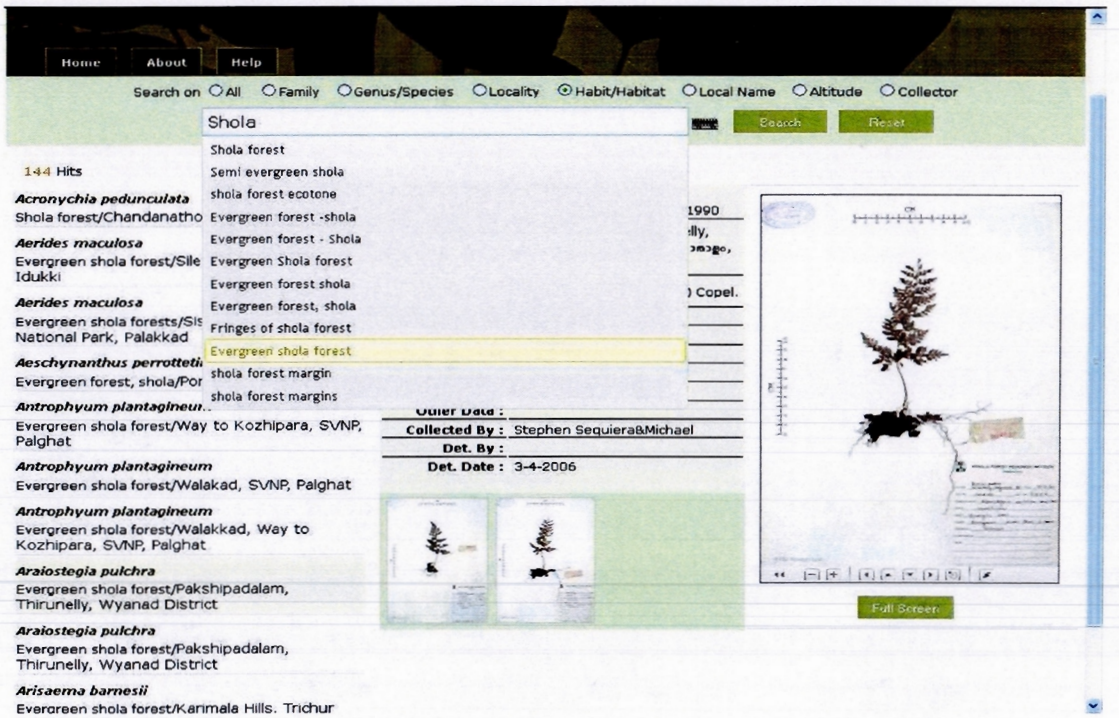


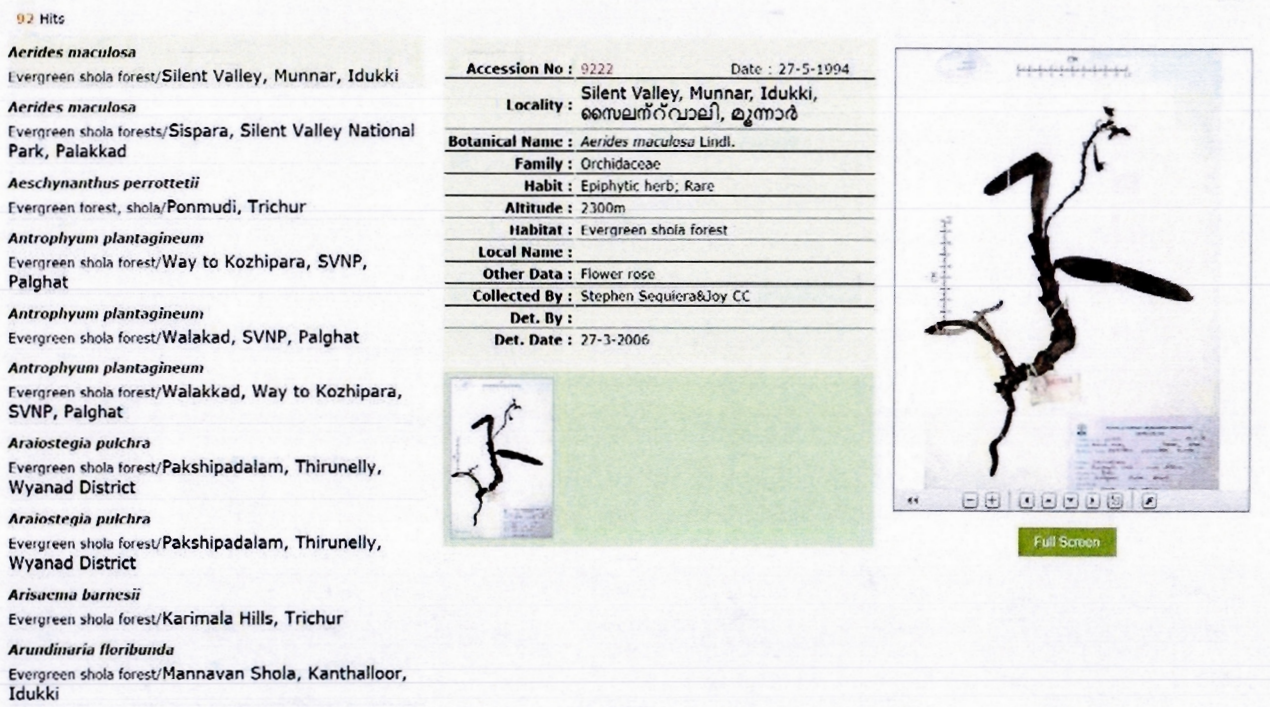
Search in genus/species wise



Search in Habit/Habitat wise

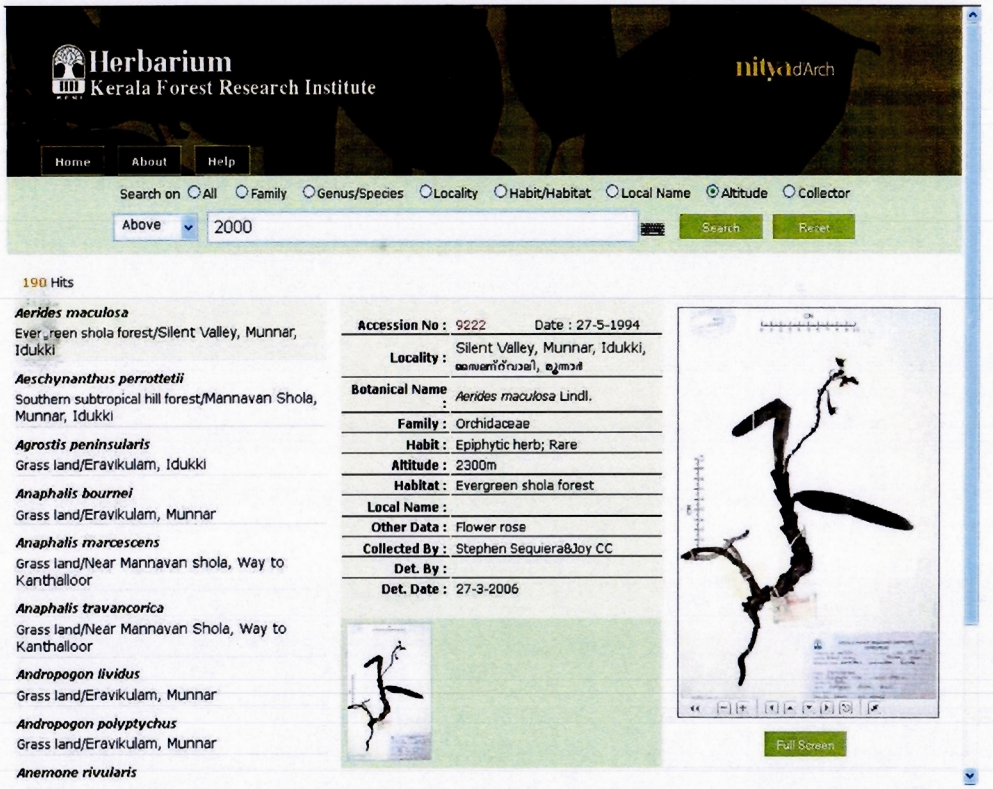
For search in habit or Habitat wise queries can be given river, mangrove, evergreen forests, Shola etc., or solitary, clustered, herb, shrub, tree etc., can be used.





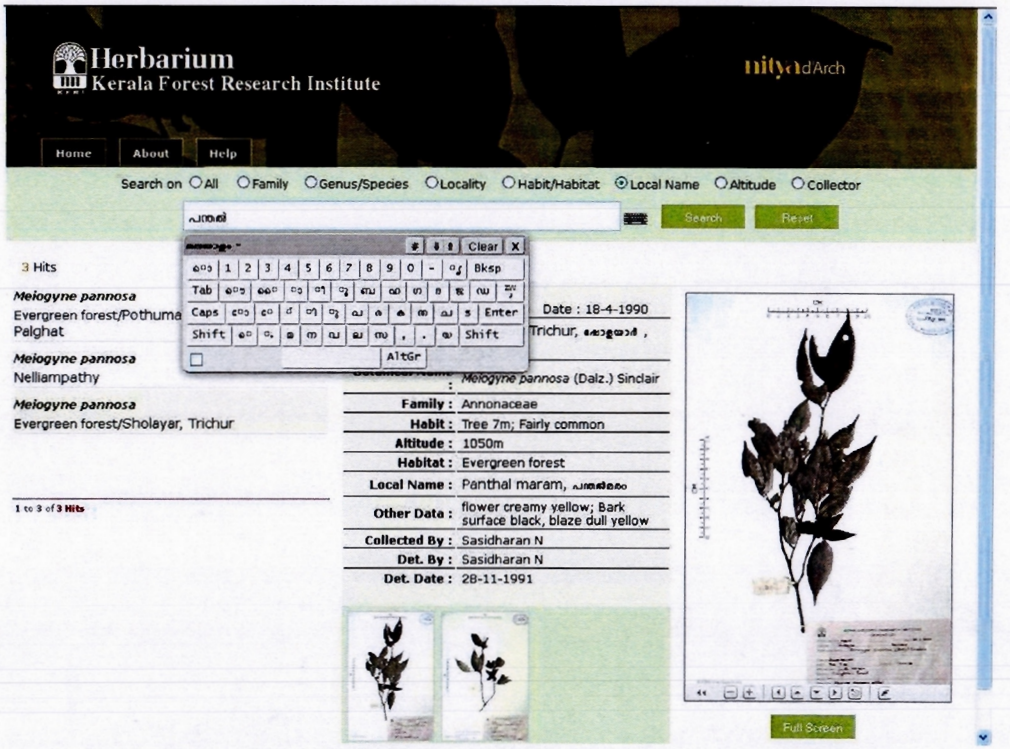
Search in altitude wise

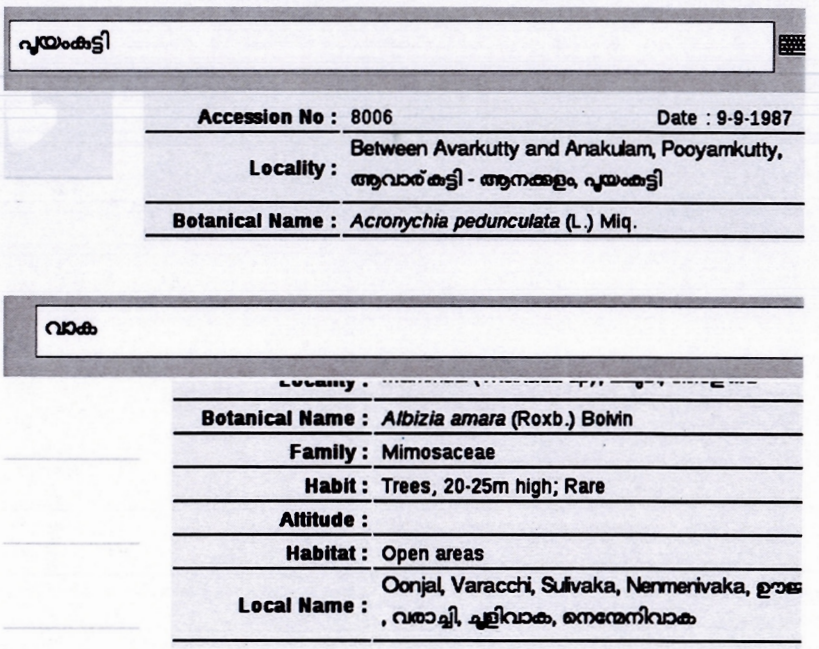
There are four sub-categories for altitude wise search. We can search the plants 'exact, above, below, between' categories. Hence, altitude wise search can be implemented by selecting exact, above, below or between options as seen in the left of the search window. For example search above 2000m altitude retrieves 180 hits.



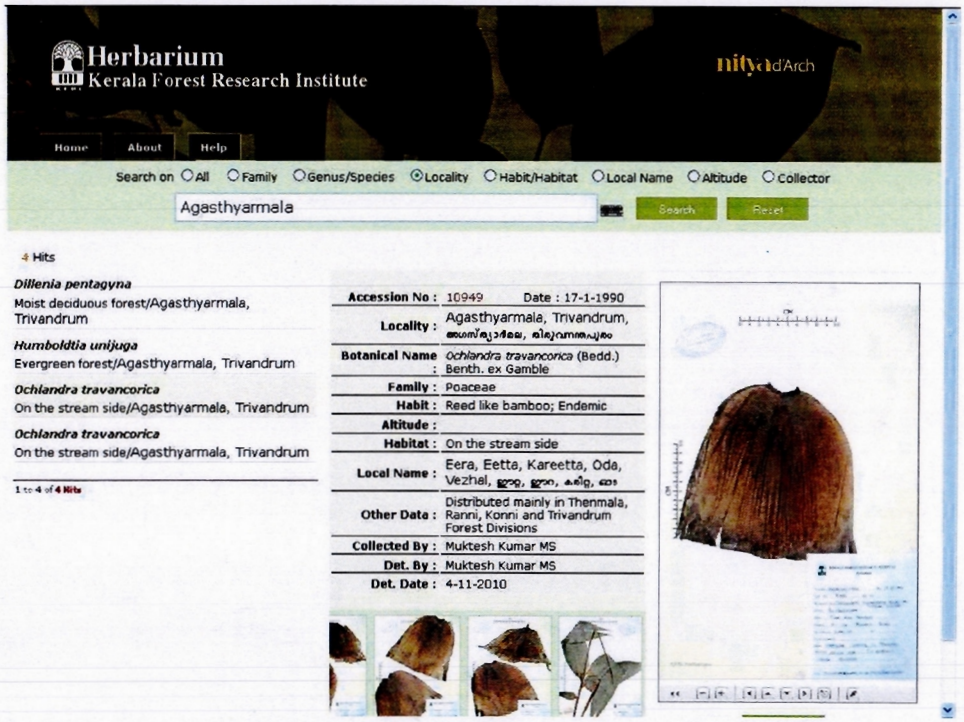
Search in Malayalam

One of the important feature of this digital herbarium is search option in regional language and the information system is Unicode compliant. Local names of species and the locations are described in English as well as in Malayalam. Search through local names can be achieved by clicking keyboard menu on the left side of the search window. Clicking on Tab/Caps/Shift options in the displayed key board will help to type the Malayalam names of the plants to be searched. For example if we want to search "*panthal*" after typing the Malayalam fonts appear 3 hits as indicated below. In some cases after typing the first one or two letters a series of combination will also appear to select the appropriate name by the user.



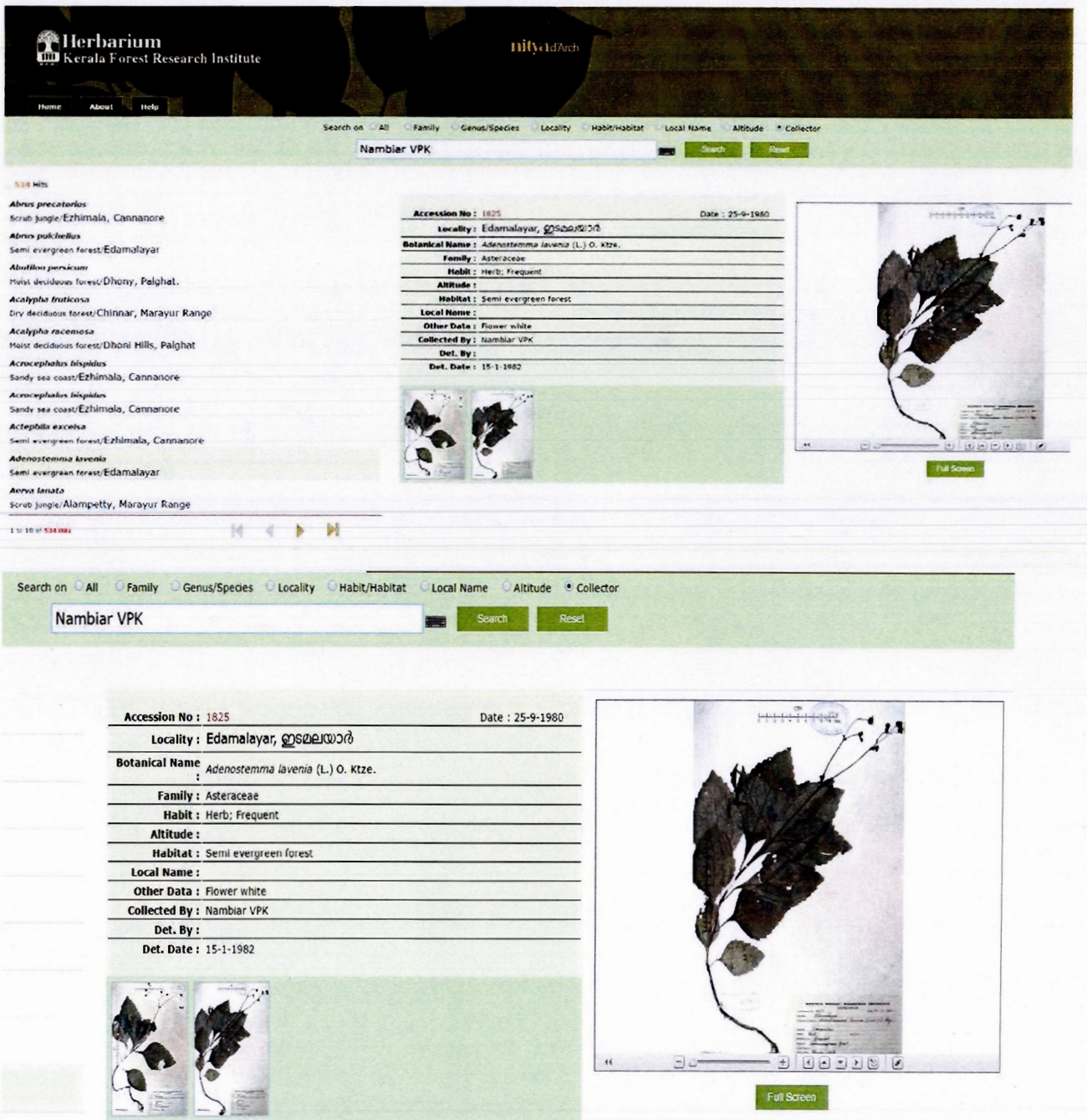


Search in Locality wise



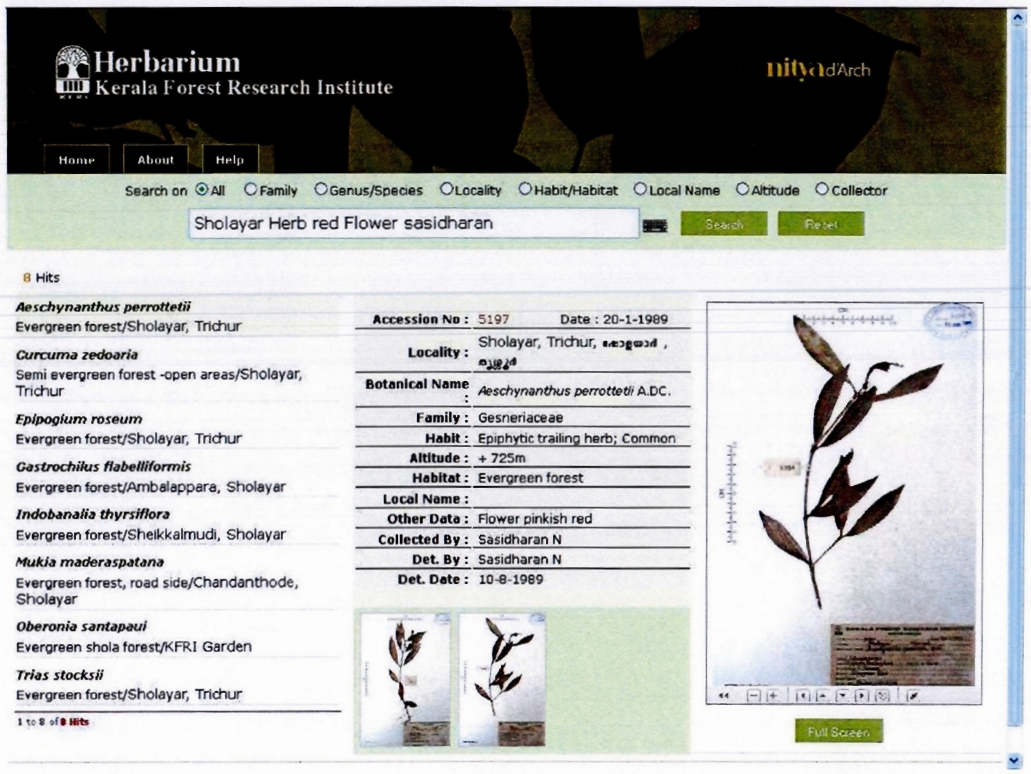
Search using name of Collector

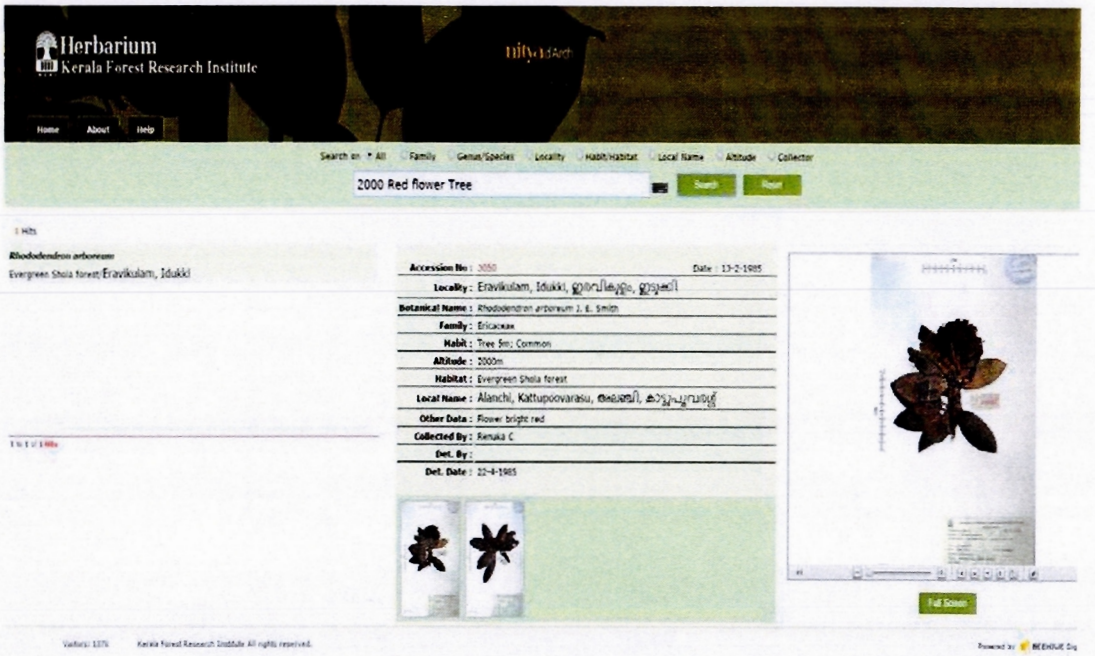
Search option using the name of collector is also possible. Any particular botanist's contribution to growth of that herbarium over a period of time can be assessed though this option.



Search in Multiple parameters

Here ALL field search is default. Multi parameters can be given separated with space, as in Google, to form query like **"River side Herb Yellow Flower".** which retrieves a unique record of species *Acroterma arnottianum.* This kind of multi-level search is not attempted in any herbarium in the web. For example 'Sholayar Herb red flower Sasidharan' query retrieves 8 hits correspond to *Aeschynanthus perrottetii*, *Curcuma zedoaria*, *Epipogium roseum, Gastrochilus flabelliformis, Indobanalia thyrsiflora, Mukia maderaspatana, Oberonia santapaui,* and *Trias stocksii.*





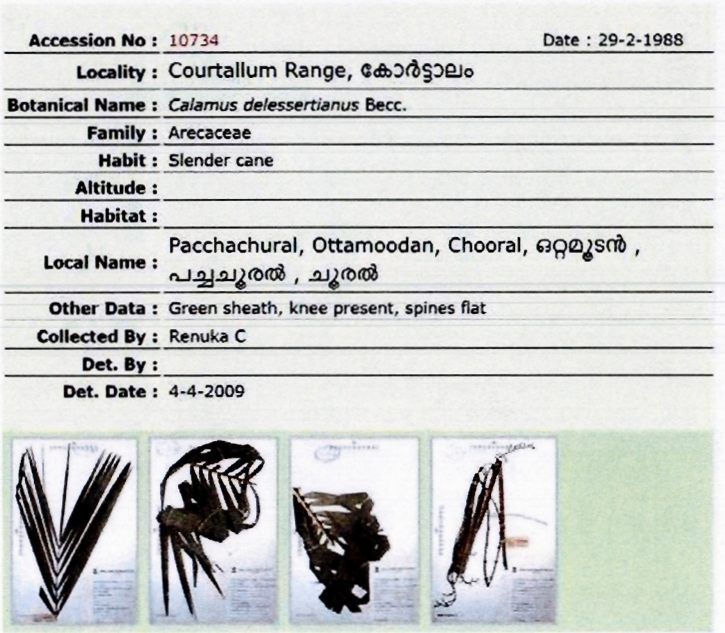
Accession No :	3050 Date : 13-2-1985
Locality :	Eravikulam, Idukki, ഇരവികുളം, ഇടുക്കി
Botanical Name :	*Rhododendron arboreum* J. E. Smith
Family :	Ericaceae
Habit :	Tree 5m; Common
Altitude :	2000m
Habitat :	Evergreen Shola forest
Local Name :	Alanchi, Kattupoovarasu, അലഞ്ചി, കാട്ടുപൂവരശ്
Other Data :	Flower bright red
Collected By :	Renuka C
Det. By :	
Det. Date :	22-4-1985

Full Screen

Powered by BEEHIVE Digital Concepts.

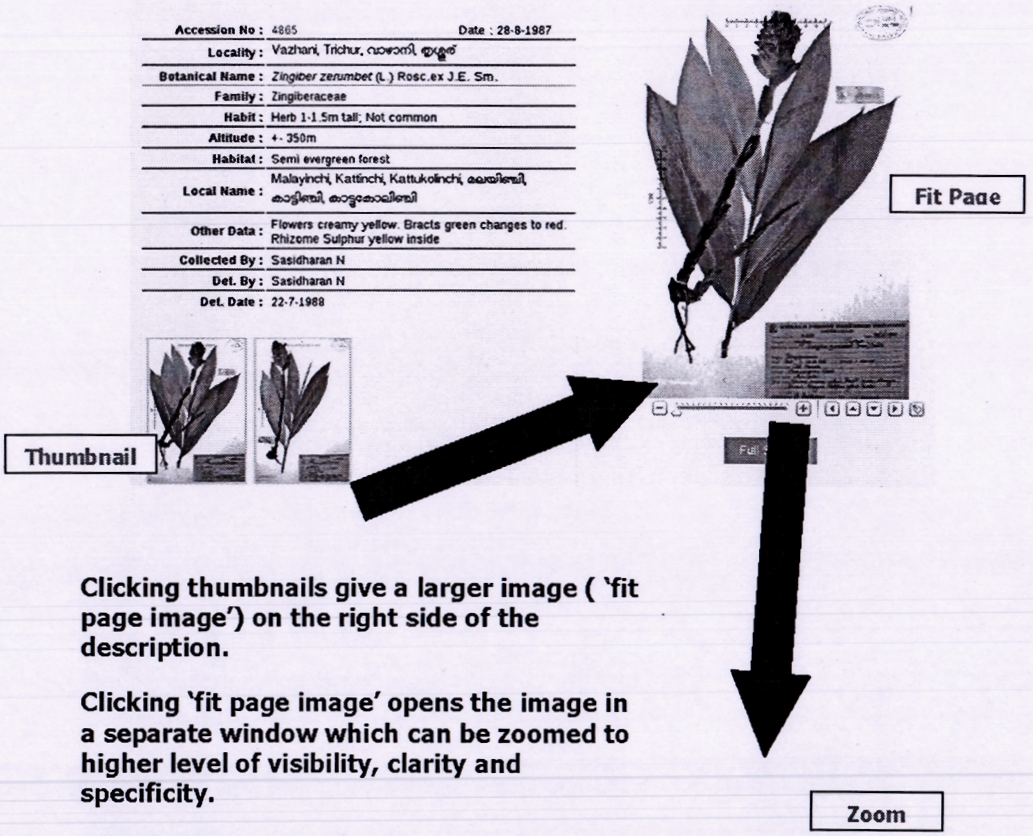
Clicking individual hit reveals

1. Full details of the specimen including Accession details, collection details, important morphological features and local names.
2. Thumbnails of herbarium sheets: In some cases several images are available for each hits representing different types sheets in a single accession. Bigger image of each thumbnail image is displayed on the right side of the window for full screen view and to enlarge the image to analyze micro-morphological features.



Accession No :	10734 **Date :** 29-2-1988
Locality :	Courtallum Range, കോർട്ടാലം
Botanical Name :	*Calamus delessertianus* Becc.
Family :	Arecaceae
Habit :	Slender cane
Altitude :	
Habitat :	
Local Name :	Pacchachural, Ottamoodan, Chooral, ഒറ്റമൂടൻ , പച്ചച്ചൂരൽ , ചൂരൽ
Other Data :	Green sheath, knee present, spines flat
Collected By :	Renuka C
Det. By :	
Det. Date :	4-4-2009

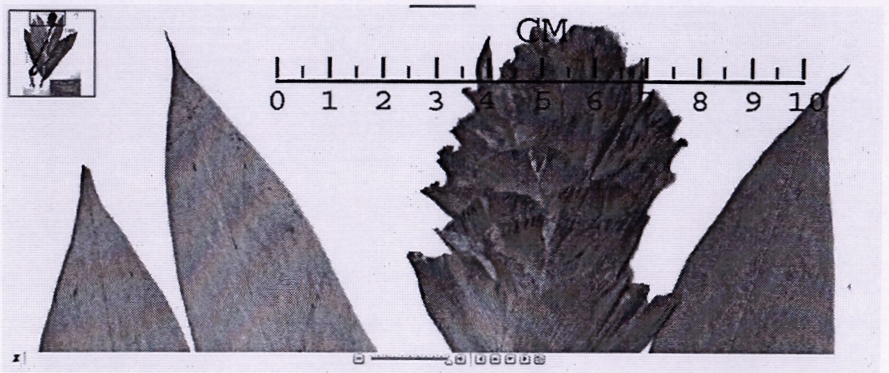
Zooming the Image

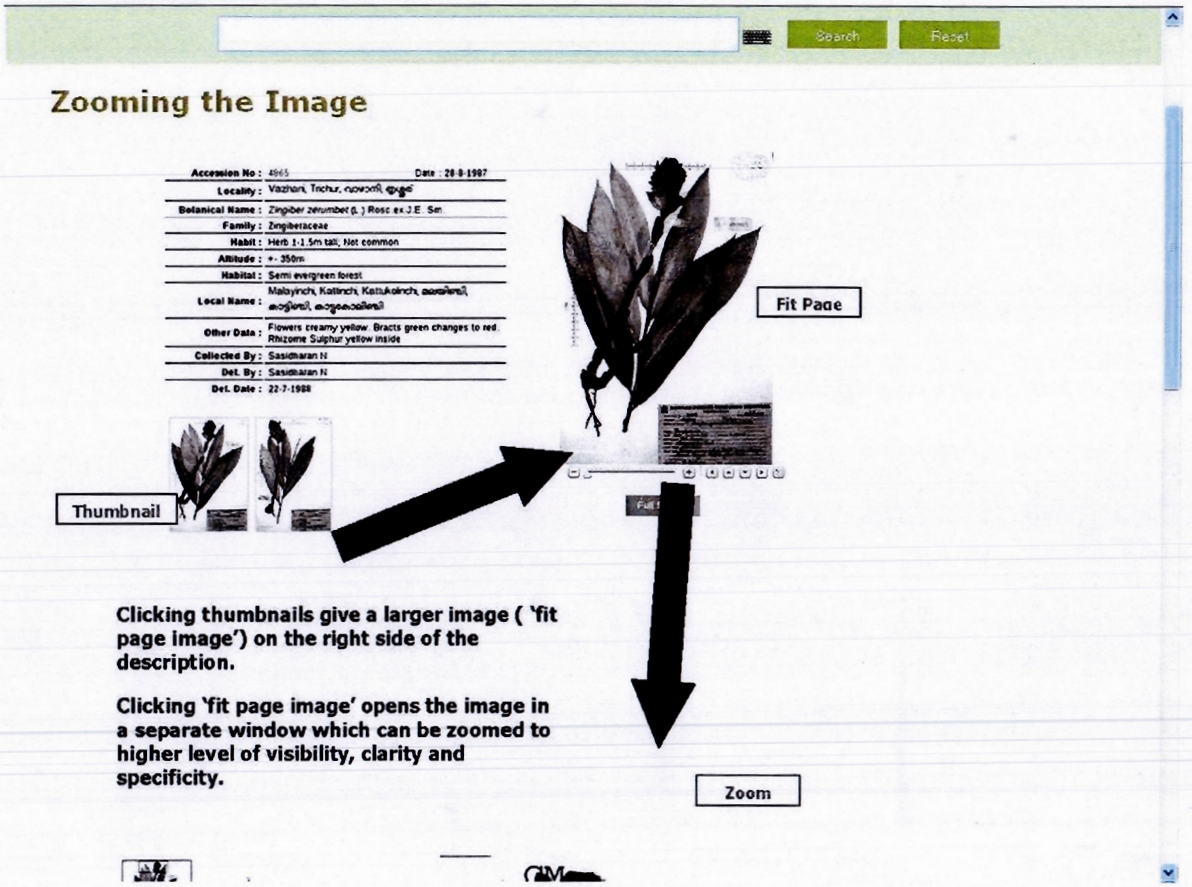


Clicking thumbnails give a larger image ('fit page image') on the right side of the description.

Clicking 'fit page image' opens the image in a separate window which can be zoomed to higher level of visibility, clarity and specificity.

Zoom




Search
Reset
Zooming the Image
Accession No : 4965 Date : 28-8-1987
Locality : Vazhani, Trichur, Kerala, India
Botanical Name : Zingiber zerumbet (L.) Rosc ex J.E. Sm.
Family : Zingiberaceae
Habit : Herb 1-1.5m tall, Not common
Altitude : +- 350m
Habitat : Semi evergreen forest
Local Name : Malayinchi, Kattinchi, Kattukolinchi, കാട്ടിഞ്ചി, കാട്ടിഞ്ചി, കാട്ടുകോലിഞ്ചി
Other Data : Flowers creamy yellow. Bracts green changes to red. Rhizome Sulphur yellow inside
Collected By : Sasidharan N
Det. By : Sasidharan N
Det. Date : 22-7-1988
Fit Page
Thumbnail
Clicking thumbnails give a larger image ('fit page image') on the right side of the description.
Clicking 'fit page image' opens the image in a separate window which can be zoomed to higher level of visibility, clarity and specificity.
Zoom


CM
1 2 3 4 5 6 7 8 9 10
CM
0 1 2 3 4 5 6 7 8 9 10
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KERALA FOREST RESEARCH I
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Conclusion

The KFRI herbarium database provides a comprehensive high quality information system on plant resource in the state. The availability of online digital images will form an indispensable part of primary data provision for floristic research, and that it will strongly influence the work practice of the professional botanists. Moreover this online database will have tremendous impact on research and education in plant systematics, ecology, plant community analysis, phenological studies, environmental sciences, agriculture, and forestry. Furthermore, regular updating of this database will provides access to data on plant diversity of a region(s) or on the collection that the herbarium has in its care.

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