

## The Universiti Brunei Darussalam biological collections: history, present assets, and future development

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**Abstract.** The Universiti Brunei Darussalam Museum and Herbarium are two small zoological and botanical university collections that started in the 1980s, mainly as research facilities. They contain collections and type material from northern Borneo that are of historical and scientific interest, and have received the contributions of several internationally renowned researchers. We here provide a first account of the history, recent activities, current state, present assets, and possible future developments of these two natural history collections. A brief review of the Southeast Asian natural history museums and collections, including herbaria, highlights the scarcity and importance of natural repositories of biodiversity in this region, one of the world's richest biodiversity hotspots.

**Key words.** museums, Southeast Asian biodiversity repositories, Kuala Belalong Field Studies Centre, type material, botanical and zoological collections, Brunei Darussalam

### INTRODUCTION

Natural history museums are the single physical source of primary information and material on past and present biodiversity (Chalmers et al., 1999). The two main goals of these institutions are to (i) act as repositories of scientific information and material, adopting conservation standards and protocols to prepare, preserve, deposit, catalogue, and monitor biological samples and (ii) make their collections accessible to users worldwide, following safe examination and loaning protocols. One of the primary objectives of curatorial scientific protocols and activities is to prevent and resolve potential conflicts between these goals (Chalmers et al., 1999).

The basic and applied scientific value and societal impact of natural history museums and collections are high, although often not recognised (Suarez & Tsutsui, 2004). The last 300 years of biological descriptions clearly show that the age of discovery is still ongoing. From 2000 to 2009, 15,000–20,000 new species have been described each year (IISE, 2011), and the present number of described species (about 1.9 million) represents only 15% of the estimated total number (Mora et al., 2011). Biological collections also form the basis for the study of biodiversity, habitat and global change. They are the focus of studies on sustainable use of the environment and food security, by providing information on the demographic history, sources and reservoirs of pathogens and disease vectors, contaminants, and prevention of agricultural

bioterrorism (Suarez & Tsutsui, 2004). Availability of natural history collections and their online resources often eliminates the need for field surveys, globally saving research institutions and governments billions of US dollars (Suarez & Tsutsui, 2004).

Southeast Asia includes the Indo-Burma, Sundaland, Wallacea, and Philippines biodiversity hotspots, four regions of major conservation interest characterised by high degrees of endemism and habitat loss (Myers et al., 2000). An online search retrieved 146 active institutions hosting natural collections in the whole region (26 natural history museums, 74 herbaria, and 48 research collections), distributed in a land area of ca. 4,326,153 km<sup>2</sup> in ten countries (CIA 2017; Table 1). Four of the largest natural history collections in Southeast Asia are the Lee Kong Chian Museum (formerly the Raffles Museum) in Singapore, with > 1 million specimens (Ng, 2000; 2015; LKCNHM, 2017); the Bogor Zoological Museum in West Java, with > 2.5 million specimens (MZB, 2009); the Herbarium Bogoriense (BO) in Cibinong Indonesia, with > 1 million specimens (LIPI, 2017); and the Singapore Botanic Gardens Herbarium (HRB), with ca. 750,000 specimens (SGB, 2017). As a comparison, the United States has 304 natural history museums in a land area of 9,147,593 km<sup>2</sup> (Grimes et al., 2015; CIA, 2017); its largest collection alone, the Smithsonian National Museum of Natural History in Washington D.C., contains ca. 80 million specimens (NMNH, 2017).

### HISTORY OF THE UBD MUSEUM AND HERBARIUM

The Universiti Brunei Darussalam (UBD) was founded in 1985 and its Faculty of Science (UBD FOS) was established in 1987. Before 1991, animal and plant specimens that were collected by the staff of the Biology Department were kept

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in the respective staff offices. Plants were mostly collected by David S. Edwards, and animals by Joseph K. Charles, Satish C. Choy, and Albert G. Orr. Webber E. Booth collected both animals and plants, including marine algae.

In 1991 and 1992, a large scientific expedition, organised by UBD and the Royal Geographical Society of London, and which included more than 70 scientists from different institutions, was conducted in rainforests of the Amo mukim [= subdivision], in the Temburong district. Several small permanent forest plots were also established during that time in the same area in Bukit Belalong by Colin Pendry, resulting in many, mostly sterile, plant collections. The expedition was followed by the Conference on Tropical Rainforest Research, organised at UBD in 1993. In the proceedings (Edwards et al., 1996) several researchers contributed with studies on components of the biodiversity, ecology, and socio-economics of the rainforests of Brunei Darussalam. Examples included studies on herbaceous ground flora (Axel D. Poulsen), wild bees (David W. Roubik), birds (Clive F. Mann), trees (Axel D. Poulsen, Ivan C. Nielsen, Sylvester Tan, Henrik Balslev), micromammals (Joseph K. Charles), forest dynamics (Colin A. Pendry, John Proctor, Sheila M. Ross, Alan P. Dykes), termite assemblages (David T. Jones), freshwater fishes (Satish C. Choy, Salwana A. Latif, Young N. Yung), herpetofauna (Indraneil Das), and ethnobotany (Jay H. Bernstein). In the same years, the Kuala Belalong Field Studies Centre (KBFSC; Amo mukim, Temburong) was established inside the newly established Ulu Temburong National Park (Batu Apoi Forest Reserve, Temburong) while several permanent 1-hectare plots were set up in forests of western Brunei by Peter Becker and his research fellow Stuart Davies. In 1994–1995, UBD relocated to its present location, and the UBD Museum (UBDM) and Herbarium (UBDH) were established, under the supervision of Helen Y.K. Pang and David S. Edwards. The founding objectives of the two institutions were to provide student, academic staff, and visiting scientist access to samples for teaching and research. Initially the main purpose of the herbarium and the zoological collections was to support identification and enable future reference for scientific study. This was fueled by the need to deposit specimens by the early wave of expeditions. However, as the number of students enrolled at UBD grew, so did the importance of the collections as a teaching tool.

The oldest UBDH voucher was collected on 3 January 1985 by David S. Edwards, who focused mostly on lycophytes and ferns, and remained the main collector for UBDH up to ca. 1991. From 1991 onwards, the diversity of collectors and collections increased in an irregular manner to its current number of 9,862 data-based specimens (Fig. 1). Permanent plot collections from 1991 (Colin Pendry), 1992 (Peter Becker and Stuart Davies), 1997 (Claire Hemingway), and 2012 (Kamariah A. Salim) resulted in thousands of plant specimens. Several other people contributed with collections of terrestrial plants (Kamariah A. Salim, Koon M. Wong, Sylvester Tan and UBD students), marine algae (Webber E. Booth), and bryophytes (Noramaliyana Haji Manaf and Mohamed Abdul Majid). These efforts led to a steady

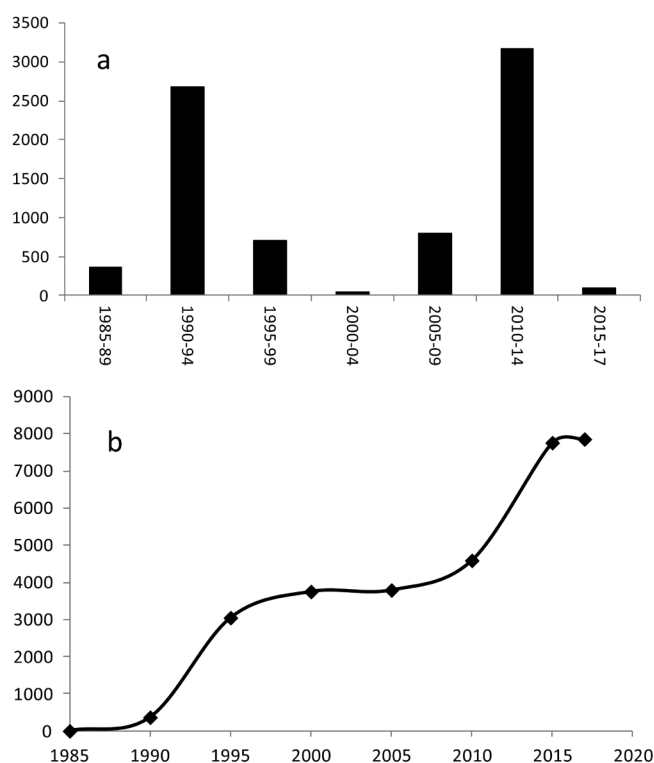


Fig. 1. UBDH botanical collections (excluding bryophytes) deposited (a) at five-year intervals, and (b) cumulatively.

growth of the UBDH collections over the years (Fig. 1). From 1998 to 2003, Kamariah A. Salim, Helen Y. K. Pang, and David S. Edwards were in charge of the UBDH and created a specimen database. UBD technicians visited the Kew Gardens and the Brunei National Herbarium (BRUN) to attend botanical specimen management courses. From 2003 to 2009, Kamariah A. Salim was director of the KBFSC and several specimens from the Ulu Temburong National Park were deposited in UBDH. The botanical studies conducted in this period, including the examination of these collections and those deposited in BRUN, led to the first field guide to the forest trees of Brunei Darussalam (Ashton et al., 2003).

Due to the lack of formal arrangements with the Brunei Museum, most animal samples from the Batu Apoi rainforest expedition (1991–1992) were deposited at UBDM. Following this expedition, additional specimens included bats collected by Charles M. Francis and Christopher P. Kofron; fishes, gastropods and crustaceans collected by Satish C. Choy and Webber E. Booth, with taxonomic contributions by John R. Hanley; termites collected by David Jones; butterflies and odonates by Albert G. Orr and Charles Clark; and snakes and frogs by Indraneil Das, sorted and identified by Robert Frederick Inger. These and other collections in the same area were published in several publications (Choy, 1989; 1990, 1993, 1996; Choy & Booth, 1994; Choy & Chin, 1994; Cranbrook & Edwards, 1994; Choy et al., 1996; Booth et al., 1997; Kofron, 1997, 2002; Wowor & Choy, 2001). Loan exchanges with Australian and United States museums were also conducted in this period. Until 2006, UBD staff continued to deposit specimens in the UBDM, such as fruit flies, gastropods, crustaceans, and fishes by Chua K. Heng, insects by David J. Marshall, echinoderms

and cnidarians by David J. W. Lane, frogs and reptiles by Ulmar Grafe. Several researchers also visited the UBDM and deposited or identified specimens in this period, such as Peter K. L. Ng and Tan Heok Hui from the National University of Singapore, Peter Davie from the Queensland Museum, and the KBFSC Research Fellow Jan Beck, who deposited a collection of moths and butterflies (Beck, 2007, 2008). Non-professional naturalists, schools, local and foreign institutions, as well as diplomats also visited the UBDM collection in this period, such as the butterfly enthusiast Japanese ambassador Yoshinobu Nisaka, and the spider expert Singapore High Commissioner Joseph K. H. Koh. Between 2006 and 2015, research activity slowed down at UBDM, with the exception of collections of aquatic insects, cnidarians, echinoderms, and amphibians (Dehling & Grafe, 2008; Zettel et al., 2008; Grafe & Keller, 2009; Benzoni et al., 2014) and the museum was used primarily for teaching.

In 2014, Ferry Slik was appointed UBDH curator, and in 2015, Gianluca Polgar was appointed UBDM curator, followed by Ulmar Grafe in 2017. The present focus of the UBDM and UBDH curators is to promote research activities, and the facilities are being restored to meet scientific standards. As stated in the 2017 Collection Management Policy of the UBDM, the UBD museums are dedicated to the study of the natural world built on basic research in natural history, botany and zoology, with an emphasis on Brunei Darussalam and Borneo, and are committed to disseminating that knowledge to the public. Furthermore, both the Faculty of Science and the Institute of Biodiversity and Environmental Research (IBER), the latter established in 2014, envision global competitiveness and excellence in biodiversity research as a strategic goal (Discover UBD, 2016).

#### RECENT ACTIVITIES OF THE UBDH AND UBDM (2015–2017)

When Ferry Slik became UBDH curator in 2014, the specimen database had not been maintained for several years and there was a backlog of uncatalogued specimens. With the use of volunteers, the specimen database has been updated to include almost all the collections present in the herbarium. Additionally, photographs of all the specimens were taken and most specimens were geo-referenced, with the aim of creating an online virtual herbarium. The whole collection was rearranged to reflect the latest plant classifications (Christenhusz et al., 2011; The Plant List, 2013; APG IV, 2016; Guiry & Guiry, 2017), and all (mostly sterile) permanent plot specimens were merged with the (mostly fertile) botanical specimens, with the aim of making the herbarium more useful for plant identification purposes. Ferry Slik also deposited ca. 16,000 sterile plant collections from East Kalimantan that are currently being catalogued. New collections have regularly been deposited by students working on medicinal plants and forest plots in this period. The entire UBDH collection of ferns and lycopods (more than 890 specimens) was mainly collected and organised by David S. Edwards. A book with a checklist of the ferns and lycopods of Brunei Darussalam, based on this collection, is currently in preparation by Daniele Cicuzza in collaboration

with BRUN and the Singapore Herbarium (SING). Daniele Cicuzza also deposited approximately 700 collections of ferns and lycopods from the tropical prefecture of Xishuangbanna, South Yunnan, China, that are currently being mounted, photographed and catalogued. Following the Heart of Borneo expedition in 2017 to Tama Abu, Sarawak, Malaysia, Daniele Cicuzza also deposited 200 collections of ferns and lycopods, including many new records for Sarawak. A new conservation regime is now implemented in the herbarium whereby the whole collection is frozen yearly, to fight and prevent pest infestations.

When Gianluca Polgar was appointed first UBDM curator in 2015, the infrastructure and collections had not been curated for several years; he attempted to revive the research activity in the museum and protect the research collection. The teaching collection and sample preparation activities were moved outside the main collection storage space. The UBDM infrastructure was restored and renovated (cabinets, furniture, doors, equipment, lighting, trapping protocols for pest insects, elimination of toxic wastes), with the help of student volunteers. Suitable environmental conditions were also reached and maintained through appropriate air conditioning and dehumidifying systems (22–23°C, 40–45% RH). Volunteers also helped to restore the dry and wet collections (jars, labels, sealing, treatments of mould, mite, and pest infestations) and to conduct a preliminary assessment of the collections; standard protocols for the preparation, deposition, preservation and examination were also established. After Ulmar Grafe was appointed UBDM curator, he started to create the UBDM catalogue, inventoried an ant reference collection by Oliver Konopik and Hanyrol Ahmad Sah, and contributed to the zoological collection with insects, reptiles, amphibians, and bats. Likewise, Gianluca Polgar contributed with a fish collection (Polgar, 2016) plus an unpublished collection of shore fishes made during a consultancy. Other researchers contributed with collections of echinoderms (David J. W. Lane) and molluscs (David J. Marshall).

Between 2016 and 2018, several informal workshops were conducted on the collection management of amphibians and reptiles. These workshops brought together biology students and technical staff from UBD as well as students from abroad to discuss and learn about techniques used to study amphibian and reptile ecology, and how to establish and maintain a reference museum collection. UBDM also aims to acquaint Bruneians and visitors to Brunei with the country's rich biodiversity. The recent loan of an insect show-case to the Brunei Biodiversity Centre must be seen as a contribution to promote environmental awareness and science-based learning opportunities in the wider community.

#### CURRENT STATUS

**UBDH Collection.** Currently the UBDH database contains 9,862 lots: 59 marine algae, 2,874 bryophytes, 890 lycopods and ferns, 1,312 fertile seed plant collections, and 4,727 (mostly sterile) permanent-plot tree collections (Table 2). These collections cover mostly the coastal and easily

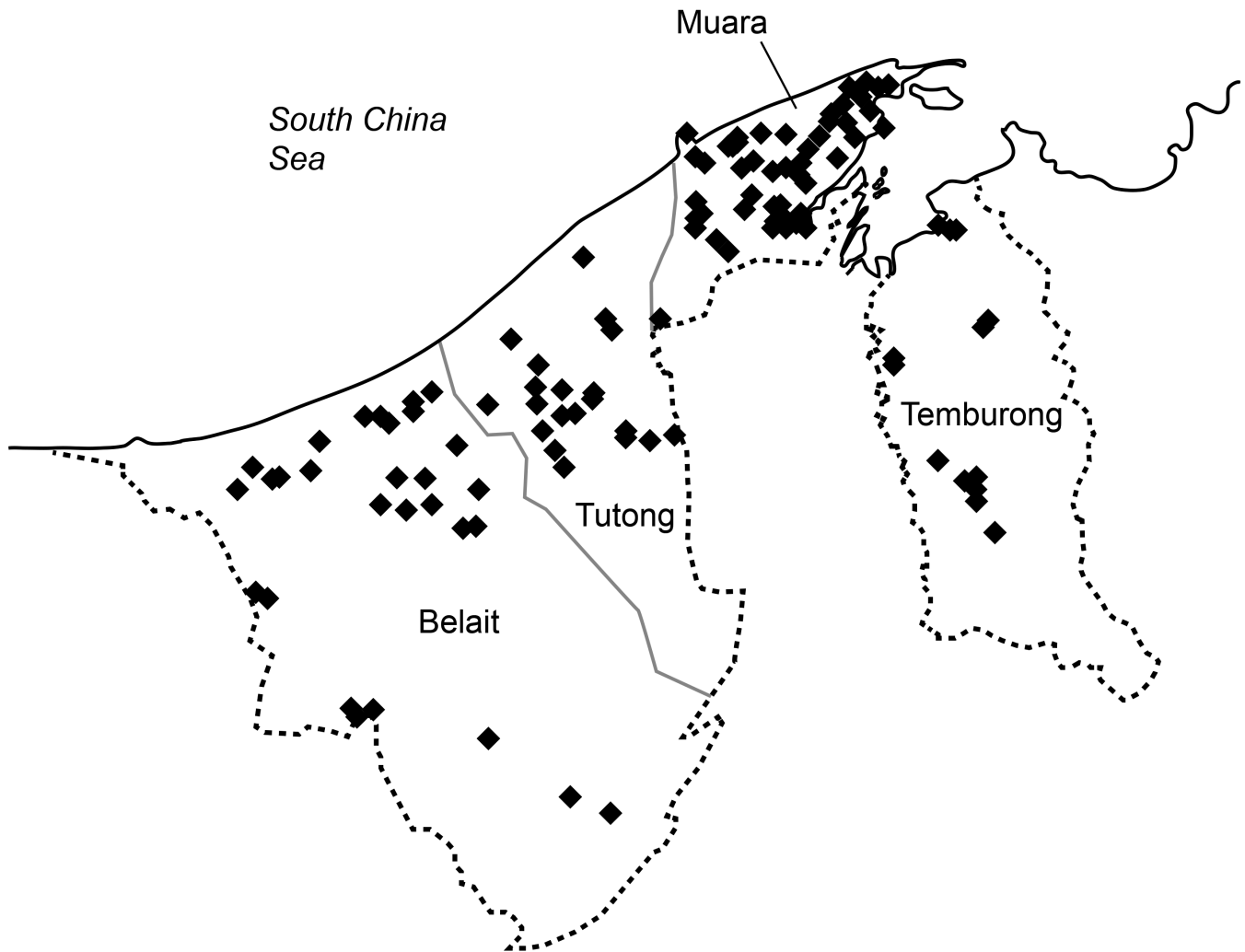


Fig. 2. Map of Brunei illustrating the collection sites of plants stored in UBDH (black diamonds); grey line: district border (districts: Belait, Tutong, Muara, Temburong); black dashed line: national border; black continuous line: coastline.

accessible areas of Brunei (Fig. 2), while most of the interior remains undersampled. Most of the collections were made in the periods 1990–1994, in association with the expeditions in Temburong and the establishment of the first permanent plot network; and 2010–2014, in association with the establishment of the CTFS plot (Fig. 1). Carpidological, alcohol and wood collections are very small and have not yet been fully inventoried, while a large number of ferns from China and trees from East Kalimantan (Indonesia) still need to be added to the database and main collection. In 2016, the whole collection was rearranged to reflect current taxonomy while all permanent plot collections (except the CTFS specimens) have been merged with the main collection. No specimens have been identified as types yet.

**UBDM Collection.** UBDM presently includes a wet and a dry collection, contained in a room with a floor area of 56 m<sup>2</sup>. An adjacent preparation room of the same size is used as a laboratory to prepare, examine and store the specimens prior to long-term conservation. The collection was contributed by UBD students and staff, as well as international researchers active in the region, such as Benito Tan (mosses, algae), Indraneil Das (amphibians), Peter Davie (brachyuran crabs),

Peter Ng Kee Lin (crustaceans), Robert F. Inger (reptiles and amphibians), and Tan Heok Hui (fishes).

The dry collection is mainly zoological, and includes hundreds of vertebrate skeletons or skeletal parts (actinopterygian fishes, mammals, birds), hundreds of whole or partial plant specimens, 76 skins (mammals, reptiles and birds), dried crustaceans and molluscan shells; these specimens are positioned on lateral benches, or contained in skin cabinets, window cabinets, and window boxes. The largest section of the dry collection is the insect collection (Fig. 3), which includes ca. 7,600 specimens contained in 133 cabinet drawers (13 orders, mainly Lepidoptera, Coleoptera, Hymenoptera); 549 specimens contained in 16 window boxes (mainly Lepidoptera, Phasmatodea, and Hemiptera); and 1,385 specimens contained in 51 small plastic boxes and a vial, in an environmentally-controlled cabinet (mainly Diptera).

In addition, the wet collection (Fig. 4) is mainly zoological and includes ca. 3,100 lots (jars and vials) on racks of shelves and lateral benches, including 1,256 (lots of) insects (19 orders, mainly Lepidoptera and Hymenoptera, including reference collections of Formicidae

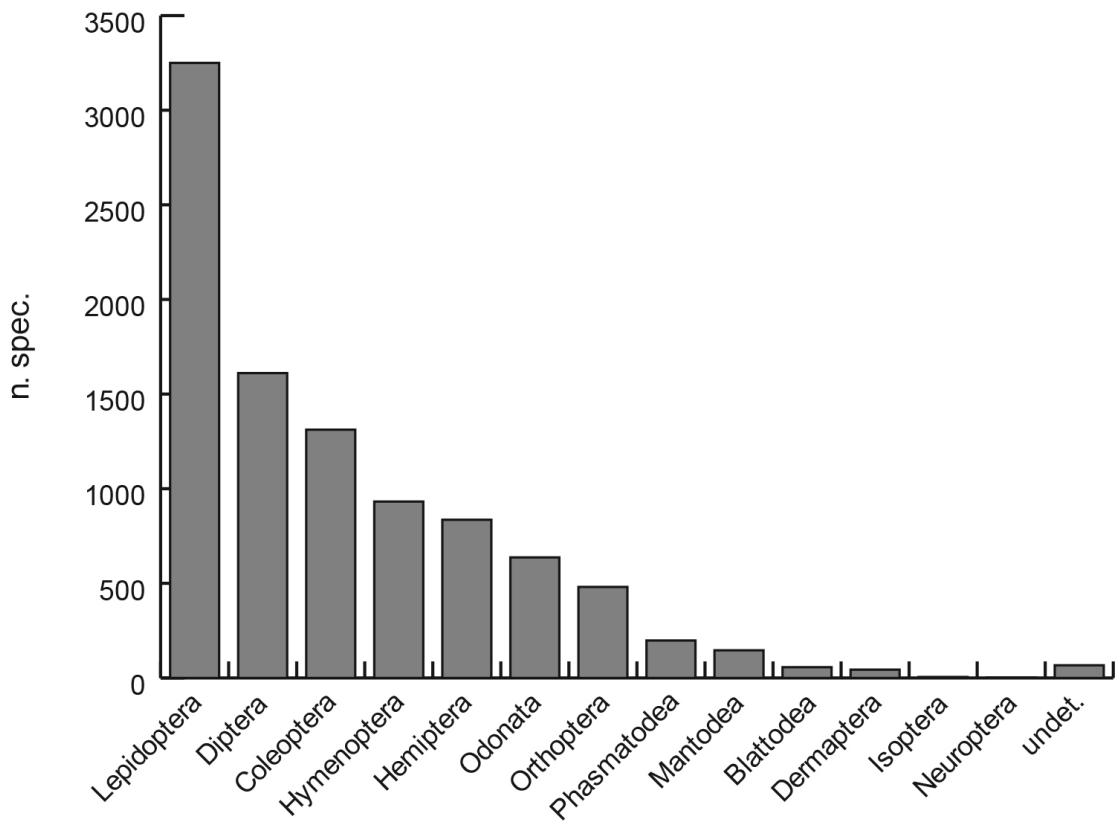


Fig. 3. UBDM dry insect collection (204 containers: cabinets, window boxes, and boxes); n. spec. = number of specimens per insect order. Damage prevented preliminary determination in some cases (undet.).

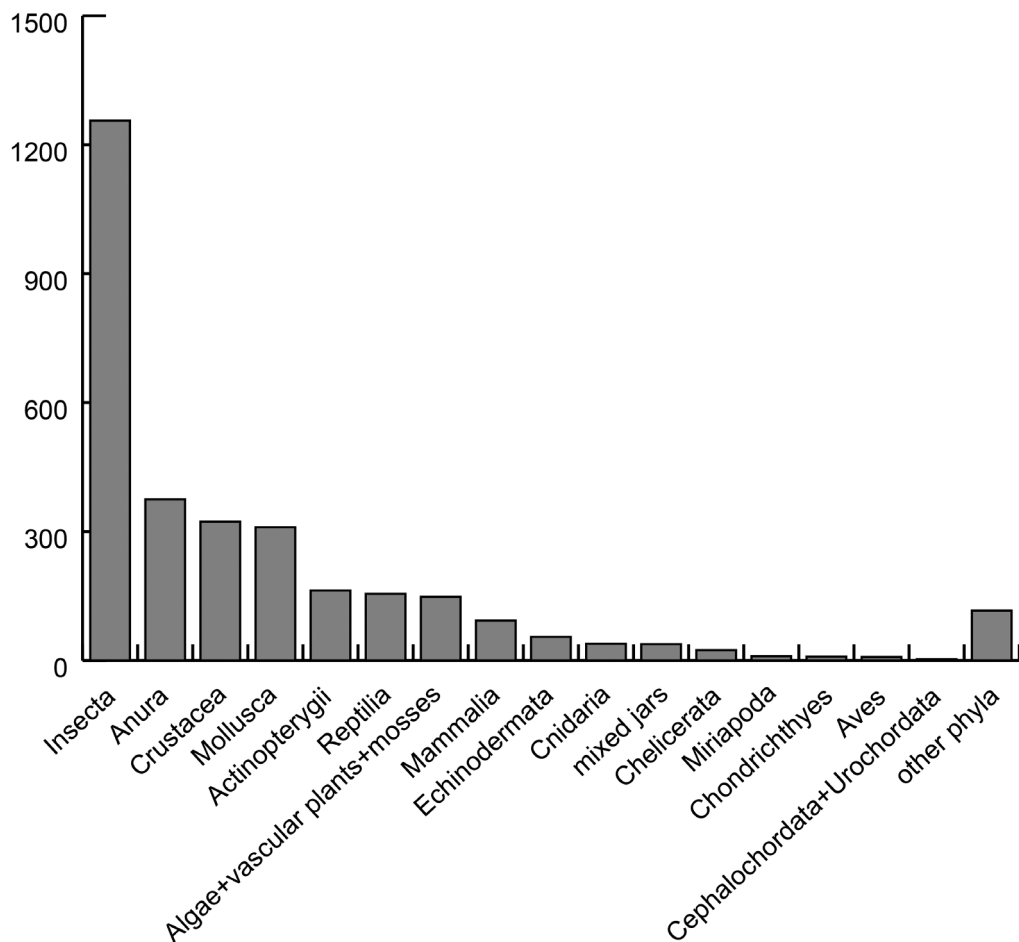


Fig. 4. UBDM wet collection. Number of lots (= jars or vials) per taxon (each lot contains one or more specimens); *mixed jars*: jars containing mixed taxa.



Table 1. List of Southeast Asian natural history museums and collections (Evenhuis, 2017; GRBio, 2017; Sabaj, 2016; Thiers, 2017). The currently used acronym is given first, followed by older or alternative ones. BOT: Botanical Collection; HRB: Herbarium; NHM: Natural History Museum; ZOO: Zoological Collection.

Country	Acronym	Name of Collection, Institution	Location	Type
Brunei Darussalam	BMKB	Brunei Museum	Kota Batu, Bandar Seri Begawan	NHM
	BRUN*	National Herbarium, Brunei Forestry Centre	Sungai [= river] Liang, Belait	HRB
	UBDH*	Universiti Brunei Darussalam Herbarium, UBD	Gadong, Bandar Seri Begawan	HRB
	UBDM	Universiti Brunei Darussalam Natural History Museum, UBD	Gadong, Bandar Seri Begawan	NHM
Cambodia	CBC	Center for Biodiversity Conservation, Royal University of Phnom Penh	Phnom Penh	ZOO
	RUPP*	National Herbarium of Cambodia, Royal University of Phnom Penh	Phnom Penh	HRB
Indonesia	ANDA*	Herbarium Universitas Andalas, Biology Department Campus of Limau Manis, Andalas University	Padang, West Sumatra	HRB
	BIOT*	Herbarium, SEAMEO-BIOTROP, Regional Center for Tropical Biology	Bogor, West Java	HRB
	BO, BZ*	Herbarium Bogoriense, Research Centre for Biology, Indonesian Institute of Sciences (LIPI)	Cibinong, West Java	HRB
	BZF <sup>a</sup> *	Herbarium, Forest Research and Development Center and Nature Conservation	Bogor, West Java	HRB
	CEB*	Herbarium Celebense, Tadulako University	Palu, Central Sulawesi	HRB
	CRDOA	Center for Research and Development of Oceanology, Indonesian Institute of Science	Ambon	ZOO
	FIPIA*	Herbarium Bandungense, Bandung Institute of Technology	Bandung, Java	HRB
	KRB*	Bogor Botanical Gardens (= Kebun Raya Bogor)	Bogor, West Java	BOT
	KRP	Purwodadi Botanical Garden	Purwodadi, Pasuruan, East Java	BOT
	LON, LON NCIP, NCIP, NCIV	Research Centre for Oceanography, Indonesian Institute of Science (= Pusat Penelitian Oseanografi, LIPI; formerly National Institute of Oceanology = Lembaga Oseanologi Nasional LIPI)	Jakarta, Java	NHM
	MALG	Herbarium Malangensis, Biology Department, State University of Malang	Malang, East Java	HRB
	MAN*	University of Papua (= Universitas Negeri Papua)	Manokwari, West Papua	HRB
MZB, LBN	Bogor Zoological Museum	Cibinong, West Java	ZOO	
PAS*	Herbarium, Java Sugar Experimental Station	Bogor, West Java	HRB	

Country	Acronym	Name of Collection, Institution	Location	Type
	WAN*	Herbarium, Forest Research Station	Balikpapan, East Kalimantan	HRB
	ZMBJ	Bandung Zoological Museum, Bandung zoo complex	Bandung, Java	ZOO
Lao PDR	FOF*	Herbarium of the Faculty of Forestry, National University of Laos	Vientiane	HRB
	HNL*	Herbier National du Laos, Conseil National des Sciences	Vientiane	HRB
	LARREC, DFV, LARRI	Living Aquatic Resources Research Center, Division of Fisheries, Department of Livestock, National Agriculture and Forestry Research Institute, Ministry of Agriculture and Forestry	Vientiane	NHM
	NUOL, FES	Zoological Collection, National University of Laos	Vientiane	ZOO
Malaysia	FRC	Forest Research Centre, Sabah Forestry Department	Sepilok, Sabah	ZOO
	FRI, IPP	Fisheries Research Institute Batu Maung, Department of Fisheries, Ministry of Agriculture and Agro-Based Industry	Pulau Penang	ZOO
	FRIGL	Freshwater Fisheries, Fisheries Research Institute Glami-Lemi, Department of Fisheries, Ministry of Agriculture and Agro-Based Industry	Glami Lebi, Jelebu, Negeri Sembilan	ZOO
	FRIM	Forest Research Institute Malaysia	Kuala Lumpur, Selangor	HRB
	IMRKL	Institute of Medical Research	Kuala Lumpur, Selangor	ZOO
	IPMB, BMRI, FRCL, UMSB, UMS	Aquarium & Marine Museum of University Malaysia Sabah, Borneo Marine Research Institute	Kota Kinabalu, Sabah	NHM
	IPPS, FRIS	Fisheries Research Institute Bintawa, Sarawak and Labuan Fisheries Research Division, Ministry of Agriculture and Agro-Based Industry	Kuching, Sarawak	ZOO
	ITBC, BORH, BORN, UMSB, UMS*	Institute for Tropical Biology and Conservation (= Borneensis), Universiti Malaysia Sabah	Kota Kinabalu, Sabah	BOT,ZOO
	KEP*	Herbarium, Forest Research Institute, Tropical Forest Biodiversity Centre	Kepong Selangor	HRB
	KLA*	Herbarium, Crop Protection and Plant Quarantine Division, Department of Agriculture	Kuala Lumpur, Selangor	HRB
	KLU*	Herbarium, Institute of Biological Sciences, University of Malaya, Rimba Ilmu	Kuala Lumpur, Selangor	HRB
	MARDI, MDI*	MARDI Agrobiodiversity Herbarium, Malaysian Agricultural Research and Development Institute	Kuala Lumpur, Selangor	HRB
	MNM, NMKL, NMM, FMSM, SM, SSMKL	National Museum of Malaysia (= Muzium Negara Malaysia)	Kuala Lumpur, Selangor	NHM

Country	Acronym	Name of Collection, Institution	Location	Type
	MUS, SBM, SMEC, SSM	Sabah Museum (= Muzium Sabah)	Kota Kinabalu, Sabah	NHM
	SAN, FRCS*	Herbarium, Forest Research Centre, Sabah Forestry Department	Sandakan, Sabah	HRB
	SAR, SFDK*	Sarawak Herbarium, Forest Research Centre, Department of Forestry	Kuching, Sarawak	HRB
	SASM, SSMKL	Sultan Alam Shah Museum	Shah Alam, Selangor	NHM
	SBC	Sarawak Biodiversity Centre Zoological Museum	Semenggoh, Sarawak	ZOO
	SMK, SM	Sarawak Natural History Museum (= Muzium Sejarah Semulajadi)	Kuching, Sarawak	NHM
	SNP, SPM*	Herbarium, Botany Section, Research and Education Division, Sabah Parks	Kota Kinabalu, Sabah	HRB
	SP, SPM	Sabah Parks Natural History Museum (= Kinabalu Park Museum), Kinabalu Conservation Centre at Kinabalu Park Headquarter	Kota Kinabalu, Sabah	NHM
	UKMB*	Herbarium, Botany Department, Universiti Kebangsaan Malaysia	Bangi, Selangor	HRB
	UKMS**	Herbarium, Biology Department, Universiti Kebangsaan Malaysia Sabah	Kota Kinabalu, Sabah	HRB
	UMKL, BIRCUM	Zoological Museum, Zoology Department, University of Malaya	Kuala Lumpur, Selangor	ZOO
	UMT	South China Sea Biodiversity Museum, Institute of Oceanography, University Malaysia Terengganu	Kuala Terengganu, Terengganu	NHM
	UMTP*	Herbarium, School of Marine and Environmental Sciences	Kuala Terengganu, Terengganu	HRB
	UNIMAS	Universiti Malaysia Sarawak	Kota Samarahan, Sarawak	ZOO
	UPM*	Herbarium, Department of Biology, Faculty of Science, Universiti Putra Malaysia	Serdang, Selangor	HRB
	USMP*	Herbarium, Universiti Sains Malaysia	Penang	HRB
Myanmar	ASM*	Herbarium, Arts and Science University	Mandalay	HRB
	MAND*	Herbarium, Agricultural College and Research Institute	Mandalay	HRB
	RAF*	Myanmar Forest Herbarium, Forest Research Institute	Yezin, Pyinmana	HRB
	RANG*	Herbarium, Yangon University	Yangon	HRB
	RAS*	Herbarium, Pharmaceutical Department, Union of Burma Applied Research Institute	Yangon	HRB
	ZMYU	Zoological Museum, Faculty of Arts and Sciences, Yangon University	Kamayut Township, Yangon	ZOO
Philippines	AQDM	Aquaculture Department Museum, Southeast Asian Fisheries Development Center	Iloilo City, Panay	NHM
	CAHUP, LBC, CALP, UPPC*	Museum of Natural History, University of the Philippines Los Baños	Laguna	NHM



Country	Acronym	Name of Collection, Institution	Location	Type
	CEBU, USCP*	Herbarium, Biology Department, University of San Carlos	Cebu	HRB
	CLP*	Herbarium, Department of Science and Technology, Forest Products Research and Development Institute	Laguna	HRB
	CMUH*	Herbarium, University Museum, Central Mindanao University	Musuan, Bukidnon	HRB
	CSCS*	Herbarium, Agricultural Biology Laboratory, College of Agriculture, Cebu State College of Science and Technology	Lahug, Cebu City	HRB
	ERDB, EBL*	ERDB Botany Laboratory and Herbarium, College of Forestry and Natural Resources, Ecosystem Research and Development Bureau	Laguna	HRB
	HNUL*	Herbarium of the Northwestern Luzon, EMDO, Office of the President, Northwestern University Inc.	Laoag City, Ilocos Norte	HRB
	IRRI	International Rice Research Institute	Manila	HRB
	MSI, GTV*	Gregorio T. Velasquez Phycological Herbarium, Marine Sciences Center, University of the Philippines, Diliman Campus	Quezon City	HRB
	MSI, UPMSI	Marine Science Institute, University of the Philippines, Diliman Campus	Quezon City	ZOO
	NLUH*	Northern Luzon University Herbarium, Division of Natural Sciences and Mathematics, University of the Philippines College	Baguio	HRB
	PNBG*	Herbarium, Philippine National Botanic Garden, University of the Philippines	Siniloan, Laguna	HRB
	NMCR, PNH, PNM, PNMI, MPMP*	National Museum of the Philippines (National Museum of Natural History since 2015)	Manila	NHM
	PPC*	Herbarium, Biodiversity Center for Research and Conservation, Palawan State University	Puerto Princesa City, Palawan	HRB
	PUH*	Jose Vera Santos Memorial Herbarium, Institute of Biology, College of Science, University of the Philippines, Diliman Campus	Quezon City	HRB
	SLUB	St. Louis University Museum	Baguio	NHM
	STUM	Museum of the Arts and Sciences, Santo Tomas University	Manila	NHM
	SUML, SUP	Silliman University Marine Laboratories	Dumaguete, Negros Oriental	ZOO
	UPLB	University of the Philippines Los Baños, Animal Biology Division, Institute of Biological Sciences	Laguna	ZOO
	USTH*	Herbarium, Research Center for the Natural and Applied Sciences, Thomas Aquinas Research Center (TARC), University of Santo Tomas	Manila	HRB

Country	Acronym	Name of Collection, Institution	Location	Type
	VSCA	Visayas State College of Agriculture	Baybay	BOT,ZOO
	WPU-PPC	Western Philippines University, Puerto Princesa City Campus, Biological Collection	Puerto Princesa City	BOT,ZOO
Singapore	LKCNHM, ZRC, ZRCS, NMS, NUS, USDZ, RMBR	Lee Kong Chian Natural History Museum (formerly Raffles Museum of Biodiversity Research)	Singapore	NHM
	SING*	Herbarium, Singapore Botanic Gardens	Singapore	HRB
	SINU*	Herbarium, National University of Singapore	Singapore	HRB
Thailand	BBH, BCC*	BIOTEC Bangkok Herbarium, National Center for Genetic Engineering and Biotechnology, National Science and Technology Development Agency	Klong Luang Pathum Thani	HRB
	BCU*	Herbarium, Botany Department, Chulalongkorn University	Bangkok	HRB
	BK*	Bangkok Herbarium, Plant Variety Protection Office, Department of Agriculture	Bangkok	HRB
	BKF*	The Forest Herbarium, National Park, Wildlife and Plant Conservation Department	Bangkok	HRB
	CMU*	Herbarium, Faculty of Pharmacy, Chiang Mai University	Chiang Mai	HRB
	CMUB*	Herbarium, Department of Biology, Chiang Mai University	Chiang Mai	HRB
	CUMZ, CUMZA, CUZM, CUB, CUB MZ	Museum of Zoology, Chulalongkorn University	Bangkok	NHM
	DMSC*	Herbarium, Department of Medical Sciences, Medicinal Plants Research Institute, Ministry of Public Health	Nonthaburi	HRB
	KKFC	Kasetsart University, Kamphaeng Saen campus, Fungus Collection	Kamphaeng Saen	BOT
	KKU*	Herbarium, Department of Biology, Khon Kaen University	Khon Kaen	HRB
	KUMF	Museum of Fisheries, Kasetsart University, Faculty of Agriculture	Bangkok	NHM
	MARNM	Maejo Aquatic Resources Natural Museum, Maejo University	Nong Han, Chiang Mai	NHM
	MFLB	Marine Fisheries Laboratory, Department of Fisheries	Bangkok	ZOO
	MFLU*	Herbarium, Center of Excellence in Fungal Research, Mae Fah Laung University	Chiang Rai	HRB
	MSUT*	Natural Medicinal Mushroom Museum, Mahasarakham University	Maha Sarakham	HRB
	NHMT, THNHM, CTNRC, TNRC, NSM	Natural History Museum, National Science Museum of Thailand	Bangkok	NHM

Country	Acronym	Name of Collection, Institution	Location	Type
	NICA	National Institute of Coastal Aquaculture	Songkhla	ZOO
	NIFI	National Inland Fisheries Institute, Fish Taxonomy Division	Bangkok	ZOO
	NRCT	National Research Council of Thailand	Bangkok	ZOO
	PBM*	Herbarium, Department of Pharmaceutical Botany, Mahidol University	Bangkok	HRB
	PMBC	Phuket Marine Biological Centre	Phuket	ZOO
	PPKU1–6	Department of Plant Pathology, Faculty of Agriculture, Kasetsart University	Bangkok	BOT
	PSU*	Herbarium, Biology Department, Prince of Songkla University	Hat Yai, Songkhla	HRB
	PSUZC	Princess Maha Chakri Sirindhorn Natural History Museum (PSU Museum, Prince of Songkla University)	Hat Yai, Songkhla	NHM
	QBG, QSBG*	Herbarium, Queen Sirikit Botanic Garden	Chiang Mai	HRB
	QSMI	Queen Saovabha Memorial Institute, Thai Red Cross Society	Bangkok	ZOO
	RAMK*	Herbarium, Biology Department, Ramkhamhaeng University	Bangkok	HRB
	RLIKU	Research Laboratory of Ichthyology, Kasetsart University	Bangkok	ZOO
	TISTR	Thailand Institute for Scientific and Technological Research, Ministry of Science and Technology	Bangkok	ZOO
	UNMF	Ubon Rajathani University Natural History Museum, Department of Fisheries	Warinchamrap, Ubon Ratchathani	ZOO
	WURC	Walailak University, Faculty of Science	Thammarat	ZOO
Vietnam	CPNP*	Herbarium, Cuc Phuong National Park	Nho Quan, Ninh Binh	HRB
	DHFRI	Dong Hai Fishery Research Institute	Dong Hai, Bac Lieu	ZOO
	DLU*	Herbarium, Da Lat University	Da Lat City, Lam Dong	HRB
	DVZUT	Department of Vertebrate Zoology, National University	Hanoi	ZOO
	HN*	Herbarium, Botany Department, Institute of Ecology and Biological Resources, National Center for Natural Sciences and Technology Cau Giay	Hanoi	HRB
	HNIP*	Herbarium, Hanoi College of Pharmacy	Hanoi	HRB
	HNU*	Herbarium, Department of Botany, Vietnam National University	Hanoi	HRB
	HNUE, HUE	Museum of Biology, Hanoi National University of Education (= Hanoi University of Pedagogy)	Hanoi	NHM
	HPNP*	Herbarium, Scientific Division, Pumat National Park	Con Cuong, Nghe An	HRB

Country	Acronym	Name of Collection, Institution	Location	Type
	IEBR, NCST	Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology	Hanoi	ZOO
	ION, OIM	National Oceanographic Museum of Vietnam, Institute of Oceanography, Vietnam Academy of Science and Technology	Nha Trang, Khánh Hòa	ZOO
	ITBCZ, ITBMZ	Institute of Tropical Biology, Collection of Zoology, Vietnam Academy of Science and Technology	Ho Chi Minh City	ZOO
	LZUH	Laboratory of Zoology, University of Hanoi	Hanoi	ZOO
	NIMM*	Herbarium, National Institute of Medicinal Materials	Hanoi	HRB
	PBB*	Phu An Herbarium, Research Center for the Conservation of Natural Resources (University) and Phu An Botanic Gardens	Phu An, Ben Cat, Binh Duong	HRB
	PHH*	Herbarium, University of Science, Ho Chi Minh City Vietnam National University	Ho Chi Minh City	HRB
	PNKB	Science Research Centre collection, Phong Nha-Ke Bang National Park	Bo Trach, Quang Binh	ZOO
	RIA1, RIAH, RIA no. 1, ARI, NCNTTSI	Research Institute for Aquaculture at Hanoi = Research Institute of Aquaculture no. 1	Bac Ninh	ZOO
	RIA2	Research Institute for Aquaculture no. 2	Ho Chi Minh City	ZOO
	RIA3	Research Institute for Aquaculture no. 3	Nha Trang, Khánh Hòa	ZOO
	SGN*	Herbarium, Southern Institute of Ecology	Ho Chi Minh City	HRB
	TDHSP	Truong Dai Hoc Su Pham (= Ho Chi Minh Pedagogical University), Zoological Collection	Ho Chi Minh City	ZOO
	UNS	University of Natural Science, Vietnam National University	Ho Chi Minh City	ZOO
	VFM	Herbarium, Vietnam Forest Museum, Forest Inventory and Planning Institute	Hanoi	HRB
	VSCA	Plant Protection Department	Hanoi	ZOO
	VNF*	Vietnam Forestry Herbarium	Hanoi	HRB
	VNM*	Herbarium, Institute of Tropical Biology	Ho Chi Minh City	HRB
	VNMN	Vietnam National Museum of Nature, Vietnam Academy of Science and Technology	Hanoi	NHM
	VNUH, CRES, DVZUT, HNUV, NUH, VUNH, ZMUH, ZMVNU	Vietnam National University, Hanoi: Zoology Museum, University of Hanoi and Department of Vertebrate Zoology, Univ. of Tông-Hop	Hanoi	NHM
	VUP	Pedagogical University of Vinh	Vinh	ZOO

\*in Index Herbariorum (Thiers, 2017)

<sup>a</sup>inactive, according to the Global Registry of Biodiversity Repositories (GRBio, 2017)

Table 2. Overview of the top 20 specimen-rich families present in UBDH for algae (total families deposited = 20, total species = 43), bryophytes (15, 53), lycopods and ferns (33, 266) and seed plants (158, 1,908). Bryophyte collections have not yet been completely identified, hence the high numbers of undetermined specimens (Undet), N = number of specimens; S/No. = number of families; Total = total number of specimens in this selection.

S/No.	Algae Families	N	Bryophytes Families	N	Lycopods and ferns Families	N	Seed plants Families	N
1	Dictyotaceae	13	Undet	2739	Polypodiaceae	123	Dipterocarpaceae	370
2	Caulerpaceae	6	Sematophyllaceae	49	Pteridaceae	98	Lauraceae	257
3	Halymeniaceae	6	Calymperaceae	43	Hymenophyllaceae	72	Euphorbiaceae	236
4	Rhodomelaceae	5	Fissidentaceae	28	Lindsaeaceae	64	Phyllanthaceae	227
5	Sargassaceae	5	Dicranaceae	3	Thelypteridaceae	59	Rubiaceae	199
6	Corallinaceae	3	Hypnaceae	2	Tectariaceae	43	Annonaceae	173
7	Gracilariaceae	3	Leucobryaceae	2	Athyriaceae	38	Myrtaceae	172
8	Liagoraceae	3	Bryaceae	1	Cyatheaceae	32	Anacardiaceae	154
9	Bonnemaisoniaceae	2	Hookeriaceae	1	Gleicheniaceae	25	Malvaceae	153
10	Cladophoraceae	2	Pilotrichaceae	1	Selaginellaceae	24	Meliaceae	151
11	Cystocloniaceae	2	Plagiotheciaceae	1	Dryopteridaceae	18	Myristicaceae	145
12	Anadyomenaceae	1	Polytrichaceae?	1	Lygodiaceae	17	Ebenaceae	143
13	Bryopsidaceae	1	Pottiaceae	1	Schizaeaceae	17	Burseraceae	141
14	Furcellariaceae	1	Rhizogoniaceae	1	Blechnaceae	12	Fabaceae	128
15	Galaxauraceae	1	Thuidiaceae	1	Dipteridaceae	11	Sapotaceae	125
16	Gelidiaceae	1			Marattiaceae	9	Moraceae	123
17	Peyssonneliaceae	1			Aspleniaceae	8	Sapindaceae	109
18	Solieriaceae	1			Lycopodiaceae	6	Polygalaceae	99
19	Udoteaceae	1			Saccolomataceae	6	Calophyllaceae	95
20	Ulvaceae	1			Ophioglossaceae	5	Clusiaceae	84
21							Fagaceae	84
<b>Total</b>		59		2874		687		3368

and Isoptera); 375 amphibians (Anura, Gymnophiona); 323 crustaceans (Anomura, Brachyura, Caridea); 310 molluscans (Bivalvia, Gastropoda, Cephalopoda); 163 ray-finned fishes (mainly Clupeiformes, Cypriniformes, Osteoglossiformes, Siluriformes, Percomorpha); 155 reptiles (Gekkota, Lacertoidea, Ophidia); 148 'algae' s.l. (e.g., Chlorophyta, Rhodophyta) plus vascular plants and mosses; 93 mammals (mainly Artiodactyla, Carnivora, Chiroptera, Primates, Rodentia, Scandentia); 55 echinoderms (Holothuroidea, Asteroidea, Echinoidea, Crinoidea); 39 cnidarians (Anthozoa, Hydrozoa, Scyphozoa); 24 chelicerates (Arachnida, Merostomata); 10 millipedes and centipedes (Myriapoda); 9 cartilaginous fishes (Chondrichthyes); 8 birds (Charadriiformes, Galliformes); 3 non-vertebrate chordates (Cephalochordata, Urochordata); and 116 less-represented phyla (Annelida, Brachiopoda, Bryozoa, Nematoda, Nematomorpha, Platyhelminthes, Porifera, Sipuncula). Thirty-eight jars contain mixed collections made in the same site and with the same method (e.g., insect plus crustaceans or molluscans netted in freshwater streams). Both the dry and wet collections mainly contain specimens from Brunei Darussalam.

#### FUTURE DEVELOPMENT

Future challenges for the development of research activities in UBDM and UBDH include (i) identifying appropriate internal and external sources of funds, (ii) improving infrastructures

and scientific equipment, (iii) streamlining administrative and bureaucratic protocols facilitating research activities and the exchange and deposition of type and non-type materials (e.g., loans, permits, import-export procedures, scientific collaborations), and (iv) employment of permanent technical and research personnel.

The current priority for UBDH is the databasing and inclusion of the ferns from China and trees from East Kalimantan (Indonesia) into the main collection. The whole collection will then be published online. Given the low sample intensity of the interior of Brunei, an effort should be made to collect in this area, but at present this can only be done when linked to new research projects. Additional collections will come from UBD student projects and newly established plots. A strong link with the newly established UBD Botanical Research Centre, whose curator currently is Daniele Cicuzza, will also be established. Currently UBDH is also working on automated plant identification techniques using leaf morphometrics. The current collections provide a good support base for future ecological and conservation studies on the forests of Brunei Darussalam. However, due to the small size and incompleteness of the current collections, taxonomic studies can currently only be done in close cooperation with the national herbarium (BRUN). When possible, multiple plant specimens are collected for UBDH and copies are deposited in BRUN, which then exchanges these materials internationally.



Table 3. List of types deposited at the UBDM. KBFSC = Kuala Belalong Field Studies Centre (Ulu Temburong National Park) [Sungai = River].

Taxon	ex	Author(s)	Collector	Locality	Date	Call number	Type
<b>Cnidaria</b>							
<i>Blastomussa vivida</i>	2	Benzoni et al., 2014	B.W. Hoeksema	E Littledale Shoal and Hornet rock, Brunei	25,27 Apr 2011	UBDM.6.00002; UBDM.6.00003	paratypes
<b>Insecta</b>							
<i>Aphelocheirus bruneiensis</i>	1	Zettel et al., 2008	S. Moore	Sungai Tutong, Brunei	15 Jun 2004	UBDM.3.00005	paratype
<i>Corethrella bicincta</i>	3	*Borkent, Grafe & Miyagi, 2012	I. Miyagi	Bario, Sarawak	2 Sept 2007	UBDM.3.00119; UBDM.3.00120; UBDM.3.00121	paratype <sup>e</sup> ; paratype <sup>f</sup> ; paratype <sup>f</sup>
<i>Corethrella bipigmenta</i>	3	Borkent & Grafe, 2012	T.U. Grafe	Sungai Temburong, Temburong; Sungai Baki, Temburong; Mata Ikan, Temburong	22 Jul 2006; 18 Jul 2008; 10 Jul 2008	UBDM.3.00111; UBDM.3.00112; UBDM.3.00113	paratype <sup>e</sup> ; paratype <sup>f</sup> ; paratype <sup>f</sup>
<i>Corethrella gilva</i>	4	Borkent & Grafe, 2012	T.U. Grafe	12 km Liang, Belait; 12 km Liang, Belait; Sungai Apan, Temburong; 12 km Liang, Belait	9 Jun 2007; 28 May 2007; 5 Feb 2010; 4 Sept 2007	UBDM.3.00122; UBDM.3.00123; UBDM.3.00124; UBDM.3.00125	paratype <sup>e</sup> ; paratype <sup>e</sup> ; paratype <sup>f</sup> ; paratype <sup>f</sup>
<i>Corethrella lutea</i>	4	Borkent & Grafe, 2012	T.U. Grafe	17 km N. Labi, Belait; Sungai Belalong, Temburong; 12.5 km Liang, Belait; 12.5 km Liang, Belait	6 Apr 2009; 7 Aug 2006; 28 Jan 2011; 28 Jan 2011	UBDM.3.00104; UBDM.3.00105; UBDM.3.00106; UBDM.3.00107	paratype <sup>e</sup> ; paratype <sup>e</sup> ; paratype <sup>f</sup> ; paratype <sup>f</sup>
<i>Corethrella mitra</i>	3	Borkent & Grafe, 2012	T.U. Grafe	Sungai Apan, Temburong	1 Jul 2008; 8 Jul 2008	UBDM.3.00114; UBDM.3.00115; UBDM.3.00116	paratype <sup>e</sup> ; paratype <sup>f</sup> ; paratype <sup>f</sup>
<i>Corethrella nanoantennalis</i>	3	Borkent & Grafe, 2012	T.U. Grafe	Lanjak Entimau, Sarawak; Lanjak Entimau, Sarawak 2 specimens	18 Jun 2008; 24 Jun 2008	UBDM.3.00108; UBDM.3.00109; UBDM.3.00110	paratype <sup>e</sup> ; paratypes <sup>f</sup>
<i>Corethrella tigina</i>	4	Borkent & Grafe, 2012	T.U. Grafe	15 km from Liang; Belait; 12 km from Liang, Belait; Mata Ikan, Temburong; 12.5 km from Liang, Belait	8 Jun 2007; 7 Jun 2007; 10 Jul 2008; 23 Mar 2009	UBDM.3.00100; UBDM.3.00101; UBDM.3.00102; UBDM.3.00103	paratype <sup>e</sup> ; paratype <sup>e</sup> ; paratype <sup>f</sup> ; paratype <sup>f</sup>
<i>Corethrella unizona</i>	2	*Borkent, Grafe & Miyagi, 2012	T.U. Grafe, T Toma	15 km Liang, Belait; Bario, Sarawak	22 May 2007; 2 Sept 2007	UBDM.3.00117; UBDM.3.00118	paratype <sup>e</sup> ; paratype <sup>e</sup>
<b>Actinopterygii</b>							
<i>Gastromyzon cranbrookii</i>	1	Tan & Sulaiman, 2006	H.H. Tan, K.K.P. Lim	Sungai Belalong, KBFSC, Temburong, Brunei Darussalam	4–7 Oct 2001	UBDM uncat. (THH-0173) <sup>d</sup>	holotype
<i>Gastromyzon cranbrookii</i>	21	Tan & Sulaiman, 2006	H.H. Tan, K.K.P. Lim	Sungai Belalong, KBFSC, Temburong, Brunei	4–7 Oct 2001	UBDM.1.00003	paratypes
<i>Gastromyzon venustus</i>	1	Tan & Sulaiman, 2006	H.H. Tan, K.K.P. Lim	Sungai Belalong, KBFSC, Temburong, Brunei	4–7 Oct 2001	UBDM uncat. (THH-0173) <sup>d</sup>	holotype

Taxon	ex	Author(s)	Collector	Locality	Date	Call number	Type
<i>Gastromyzon venustus</i>	3	Tan & Sulaiman, 2006	H.H. Tan, K.K.P. Lim	Sungai Belalong, KBFSC, Temburong, Brunei	4–7 Oct 2001	UBDM.1.00002	paratypes
<i>Neogastromyzon brunei</i>	1	Tan, 2006	H.H. Tan, K.K.P. Lim	Sungai Enkabang, upstream KBFSC, Temburong, Brunei	5 Oct 2001	UBDM uncat. (THH-0175) <sup>d</sup>	holotype
<i>Neogastromyzon brunei</i>	4	Tan, 2006	H.H. Tan, K.K.P. Lim	Sungai Enkabang, KBFSC, Temburong, Brunei	5 Oct 2001	UBDM.1.00001	paratypes
<b>Anura</b>							
<i>Rhacophorus belalongensis</i>	5 <sup>a</sup>	Dehling & Grafe, 2008	J.M. Dehling	Sungai Mata Ikan, KBFSC, Temburong, Brunei	14–15 Sep 2005	UBDM.2.00184	paratypes
<i>Rhacophorus belalongensis</i>	1 <sup>b</sup>	Dehling & Grafe, 2008	T.U. Grafe, T.C. Wagner	Sungai Mata Ikan, KBFSC, Temburong, Brunei	18 May 2005	UBDM.2.00170	paratypes
<i>Rhacophorus belalongensis</i>	7 <sup>c</sup>	Dehling & Grafe, 2008	T.U. Grafe	Engkabang, KBFSC, Temburong, Brunei	23 Jul 2007	UBDM.2.00185	paratypes

\*Published in Borkent & Grafe (2012)

<sup>a</sup>Published as GK 06-22, 06-23, 06-24 (3 males); and GK 25, GK 26 (2 adult females)

<sup>b</sup>Published as GK 06-57 (1 adult male)

<sup>c</sup>Published as G07-1, -2, -3 (3 adult females); G07-4, -5, -6, -7 (4 adult males)

<sup>d</sup>Author's call number

<sup>e</sup>on microscope slides

<sup>f</sup>on pin

The largest UBDM collections are those of butterflies, ants, crustaceans, frogs, and molluscs. These include several regional endemics, and were examined and contributed by taxonomic group experts. Deposited freshwater fishes, frogs, corals, and insects also include types, and several specimens were published as new species or first records (Tan, 2006; Tan & Sulaiman, 2006; Dehling & Grafe, 2008; Zettel et al., 2008; Borkent & Grafe, 2012; Benzoni et al., 2014; Ng et al., 2015; Lane & Hoeksema, 2016; Polgar, 2016). The deposited UBDM types are listed in Table 3.

The UBDM collection is largely uncatalogued and valuable specimens are likely to emerge from future investigations and updates of the UBDM catalogue. For example, the holotype of the caridean shrimp *Caridina temasek* Choy & Ng, 1991 was found recently in the UBDM collection. The specimen, which was published as deposited in the Raffles Museum of Biodiversity Research (now Lee Kong Chian Natural History Museum, LKCNHM) in Singapore (*vide* Choy & Ng, 1991), was still stored in the UBDM. Working with LKCNHM staff, a careful examination of the type material allowed us to confirm the identity of the specimen as the original holotype, and it is now deposited in the LKCNHM. Several taxa and types of samples are lacking, although abundant in Brunei Darussalam, offering an opportunity to enlarge and improve the collection. In particular, the mammal (skins, wet specimens) and bird collections (including nests, eggs, feathers, etc.) are very small. Collections of ethanol-preserved tissues for genetic analyses and sound databases are also

lacking. Future developments may include a photographic catalogue and an online website.

For both UBDH and UBDM, a formal loan policy is not in place. Currently, any exchange of specimens has to be approved by the Biodiversity Research and Innovation Centre (BioRIC), located at the Ministry of Primary Resources and Tourism. This procedure adds an additional administrative layer for curators and researchers to go through, and significantly restricts research activity. It would be useful to allow the UBDH and UBDM to loan specimens directly, based on pre-agreed procedures approved by BioRIC. This should also entail allowing UBDH and UBDM to obtain their own institutional CITES numbers, making scientific movement of CITES listed plants and animals possible.

UBDM and UBDH see their respective niches as generating research activities that, among others, increase our understanding of biodiversity, evolution, population genetics, and the environmental impacts of climate change. Based at a university dedicated to education and learning, the UBDM and UBDH can thrive in an environment of passionate educators and researchers that want to make the collections as accessible as possible, while maintaining their integrity. Currently, no research collaboration is in place between UBDM and the Brunei Museum, and the UBDM is the main point of contact for domestic and international zoologists alike. In contrast, BRUN maintains close research and curatorial links with UBDH, configuring a model for

future collaborations between local biodiversity repositories. Synergies between all the Bruneian museums can be achieved by further cataloguing the collections, exchanging duplicate specimens, networking, organising joint exhibits, and participating in joint expeditions. Such activities have been fruitful in the past. For example, the Sungai Ingei faunal expedition (2009–2012) brought together staff from the Brunei Museum and UBD in a common effort to survey a remote forest area, thereby facilitating links and networking.

Worldwide, small collections are struggling to cope with significant budget cuts, with some collections being neglected, damaged or lost altogether. This appeared to be the fate of the UBDM, whereas the UBDH has always received more attention. This is largely due to the greater degree of attention paid to timber forest resources, while the zoological side of natural heritage has been seen as less valuable in Brunei. Fortunately, a shift in perspective has occurred in recent years, with a major effort underway at the UBDM to maintain the integrity of the collection and catalogue its specimens. This is very welcome, given that the collections are unique in nature. Continued support by university administrators for both collections is anticipated, despite budgetary constraints. Future Bruneian generations will increasingly depend on these collections to further the scientific understanding of their national natural heritage, and address fundamental questions that will affect their livelihoods.

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