Status Report 2021

National Biodiversity Centre (NBC)
Ministry of Agriculture and Forests
Royal Government of Bhutan
Serbithang, Thimphu

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Front Cover Photo: *Cypripedium guttatum,* (L-R) Bhutan Biodiversity Portal, *Pseudonapaeus occibhutanus* (Snail), *Rodhodendron pogonophyllum, Chiloschista himalaica,* Biodiversity Interpretation Centre. **Back Cover:** Kyitsugang, Dangchu, Wangdue Phodrang.

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Message from the Program Director

In recognition of the importance of biodiversity to humankind and to its own goal of environmentally sustainable development and committed leadership in environmental conservation, Bhutan became party to and ratified the UN Convention on Biological Diversity (CBD) in 1995 by the 73rd National Assembly of Bhutan. Thus, in 1998 the National Biodiversity Centre (NBC) was established to coordinate the biodiversity conservation efforts and the National Biodiversity Strategies and Action Plans (NBSAPs). Bhutan also signed the Nagoya Protocol on Access and Benefit Sharing (ABS) in 2011 to enable meaningful ABS collaborations that will benefit country and the people at large through regulated access to biological resources of Bhutan.

This year, we are pleased to share the Centre's Status Report for the fiscal year, July 2020 to June 2021. We are presenting comprehensive conservation efforts carried out during this fiscal year to achieve the national and international targets on biodiversity conservation. With changing time, biodiversity is threatened in various ways and the Centre sees how crucial it is to strengthen its roles and responsibilities towards biodiversity conservation and its sustainable utilization. An important tool towards this effort is to enhance the knowledge and awareness of the citizens at large. Towards this end, the Centre focused on two important means i.e., it established the Biodiversity Interpretation Centre at the Royal Botanical Garden, which is first of its kind in the country. It is aimed to create more public awareness and educate on the importance of biodiversity conservation and its sustainable utilization. Further, the Centre also upgraded the Bhutan Biodiversity Portal from version 2 to version 3.

The Centre successfully micro-propagated orchid species, established several Access and Benefit Sharing initiatives with the local communities, initiated epididymal semen collection and porcine semen cryopreservation from indigenous pigs, among others.

The status report comprises rational for biodiversity conservation, achievements, Annual Performance Agreement, success stories, research abstracts and other relevant information on biodiversity of Bhutan. We thank our conservation partners and donors for assisting us to effectively conserve country's biodiversity.

We hope you will enjoy reading the report, and we welcome your valuable comments.

Dr. Karma Dema Dorji
Program Director/Specialist Head

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Rheum nobile

1. Background

1.1. Biodiversity of Bhutan

Biological diversity is vitally important for every sphere of human existence and provides us with a vast range of products and services ranging from food, water, timber, fiber, genetic resources, and medicines to recreational, aesthetic, and spiritual benefits as well as regulation of climate, water and soil quality, and pollination among others. Biodiversity is the very basis for sustainable development. In the context of Bhutan, not only has the conservation of biological diversity always played a pivotal role in Bhutan's development history but concern for the natural environment and biological diversity is deeply embedded in Bhutanese traditional beliefs, socio-cultural outlook and the overarching development philosophy of Gross National Happiness (GNH). As a result, Bhutan has emerged virtually unscathed in the twenty-first century in terms of its biological wealth.

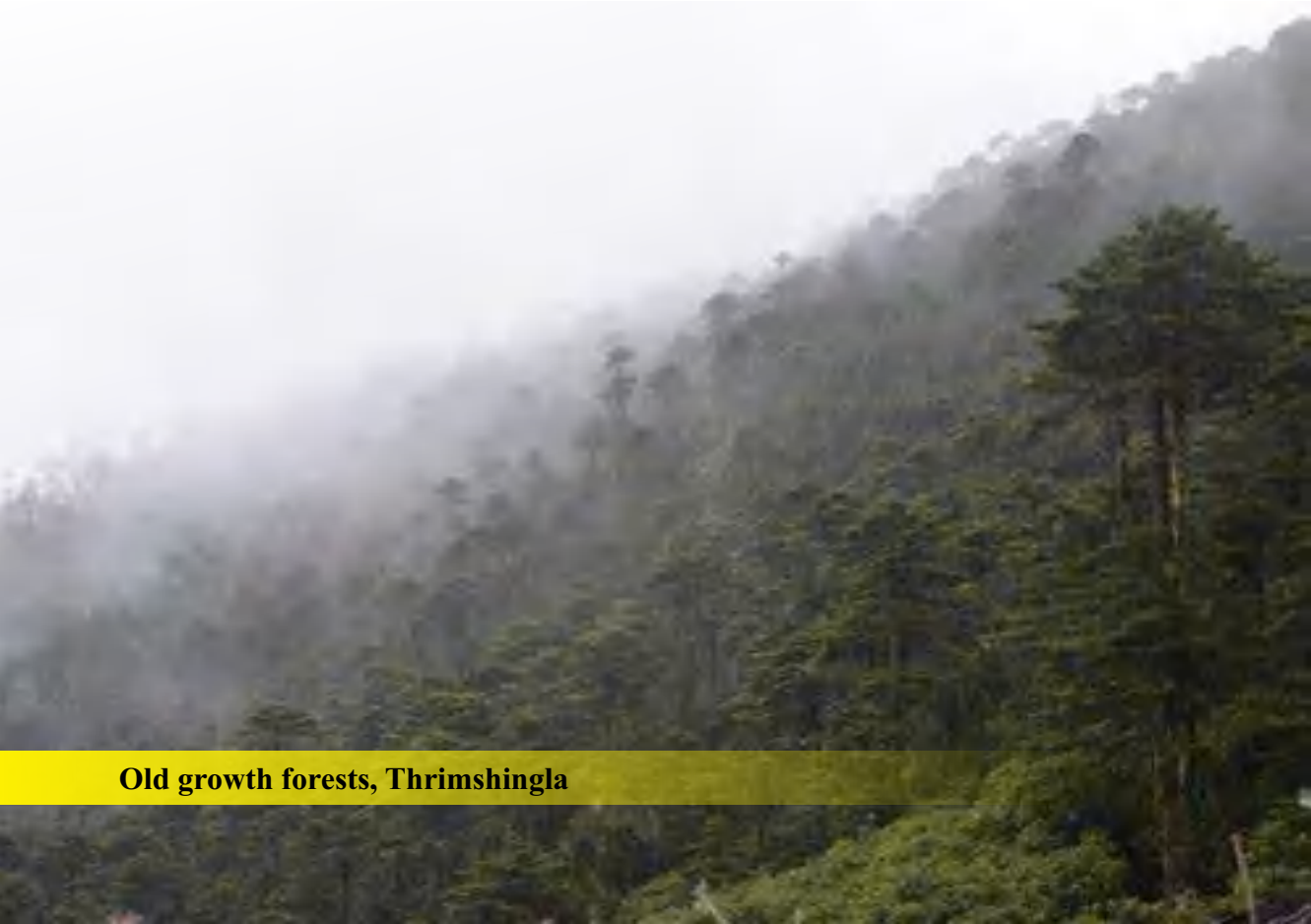
The country has 70.77 percent of the total area under forest cover and 51.44 percent secured as protected areas and biological corridors and is home to 11,248 species of flora and fauna including 4978 species of vascular plants, 3511 insects, 129 mammals, 736 birds, 125 fishes and 158 amphibians and reptiles. To date, over 300 species of medicinal plants have been found at altitudes ranging from 200 to 7800 meters above sea level. In terms of domestic biodiversity, there are more than 55 species of agriculture crops and 6 species of livestock (NBC, 2019). Some of these have adapted to the country's rugged mountains and harsh climatic conditions and, therefore, bear distinctive features which need to be conserved, especially to build resilience in the face of climate change for food security and improved livelihoods. About 79% of the Bhutanese population depends on natural resources for their livelihoods (BAP 2002) and the figure could be significantly higher if we take into account non-rural people dependent on other natural resources such as timber which justify the paramount importance of conservation and sustainable utilization of biodiversity to Bhutan and its people.

The nation's strong commitment to the environment is also apparent from the fact that the Constitution of the Kingdom of Bhutan mandates the country to maintain at least 60% percent forest cover for all time to come. Internationally as well, Bhutan has spearheaded environmental commitments such as staying carbon-neutral and fostering regional climate change cooperation and is party to many international instruments committed to protecting the biodiversity and environment such as the United Nations Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCCC) and United Nations Convention to Combat Desertification (UNCCD), International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), among others. The Bhutan Trust Fund for Environmental Conservation (BTFEC) which was established through the command and guidance of His Majesty the Fourth King is now a robust fund that has supported

and continues to support various national initiatives to protect the environment. Bhutan for Life (BFL) was established to be the strategic and long-term solution to ensure that Bhutan remains economically and environmentally sustainable forever.

Nevertheless, we cannot rest on our past laurels and remain passive in the face of emerging challenges such as fast economic growth, increasing rural-urban migration, expanding urbanization, increased need for forest resources, human wildlife conflict, climate change, land degradation, etc. which impacts biodiversity and environmental conservation in one way or the other. The increasing pressure on the nation's coffers from the growing needs of the population also has implications on the growing cost of conservation for the sake of conservation alone. We also have to be conscious of the fact that in the face of increasing erosion of biodiversity in the neighboring countries due to the constant struggle between conservation and fast socio-economic development as well as an expanding population and the threat of changing climate, the value of Bhutan's natural resources will increase in terms of relative importance presenting numerous opportunities for deriving benefits. As the loss of biodiversity is irreplaceable, the level of concerns of biodiversity in recent times is rising more than ever before and many world leaders are rethinking their priorities with respect to the allocation of resources towards biodiversity conservation.

Given these considerations, we need to invest strongly in strengthening national capacities particularly in developing a sound scientific knowledge base of our rich biological diversity and tapping the



Old growth forests, Thrimshingla

opportunities from biodiversity for effective utilization of our biological resources in a sustainable manner. Therefore, it has become of utmost importance that the country establishes and strengthens measures that will enable the country to benefit from its rich biological resources and encourage people-centric conservation to take place.

Conservation has always played a pivotal role in Bhutan's development history and concern for the natural environment and biological diversity is deeply embedded in Bhutanese traditional beliefs, socio-cultural outlook and the overarching development philosophy of Gross National Happiness.

Bhutan has one of the most rugged terrains with diverse altitudinal range and climatic conditions. Crop diversity and genetic diversity within species is important to adapt to this diverse and heterogeneous agro-ecological zones of Bhutan. The importance of crop diversity and genetic diversity is gaining more importance than ever before as part of climate change adaptation and mitigation measures. Given these considerations, it is imperative that the government invests strongly in strengthening national capacities particularly in developing a sound scientific knowledge base of the country's rich biological diversity and tapping the opportunities from biodiversity for effective conservation and utilization of our biological resources in a sustainable manner. Therefore, it has become of utmost importance that the country establishes and strengthens measures that will enable the country to benefit from its rich biological resources and promote leadership of people at grass root level in conservation.

Old growth forests, northern Bumthang

Pedicularis siphonantha

1.2. History of NBC

In recognition of the importance of biodiversity to humankind and to its own goal of environmentally sustainable development and due to the committed leadership in environmental conservation, Bhutan became party to and ratified the Convention on Biological Diversity (CBD) in 1995 by the 73rd session of the National Assembly. The CBD is one of the most comprehensive international agreements, signed by 196 countries committed to the conservation and sustainable utilization of biological resources and the fair and equitable sharing of benefits arising from the access to biological resources. Bhutan also ratified the Nagoya Protocol on Access and Benefit Sharing (ABS) in 2012 by the 9th session of the 1st Parliament of Bhutan to enable meaningful ABS collaborations that will benefit the country and the people at large through the regulated access to biological resources in the country.

With the ratification of the Convention, Bhutan developed its first Biodiversity Action Plan in 1997, as a guiding policy document for conservation and sustainable utilization of biological resources of the country. To date, Bhutan has developed and implemented four Biodiversity Action Plans- the first in 1997, second in 2002, third in 2009, and fourth in 2014 – a guiding policy document for conservation and sustainable utilization of biological resources of the country. The Biodiversity Action Plans are "living documents" that guide conservation and sustainable utilization of biodiversity in the country and are formulated every few years to evolve with the changing needs of the population and the country vis-à-vis the environment. During the course of developing the first Biodiversity Action Plan, it was recognized that responsibilities for biodiversity were divided among

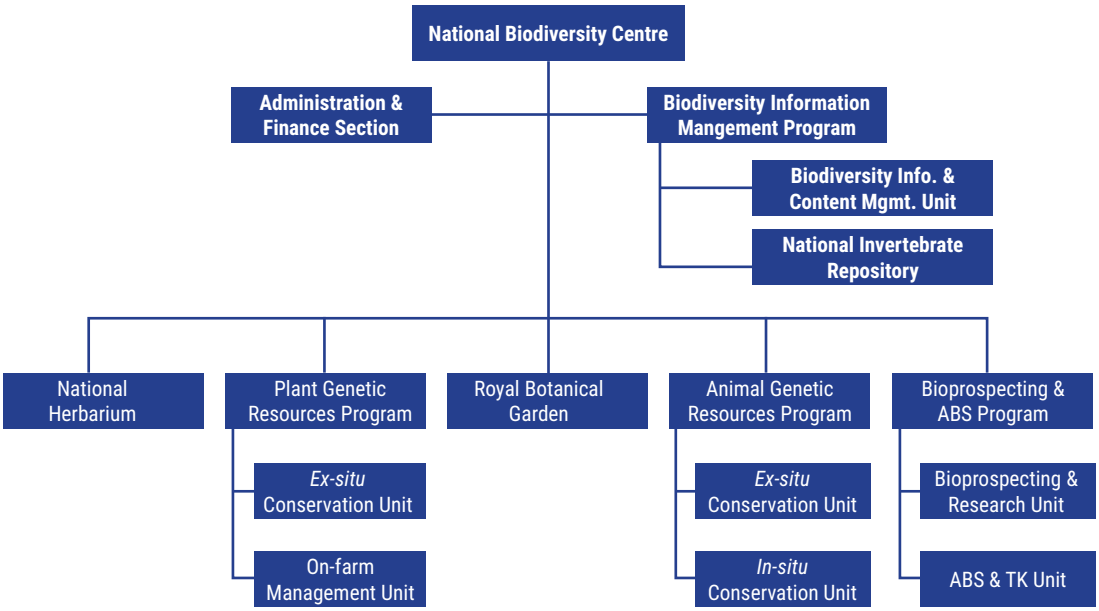
several units within the Ministry of Agriculture & Forests, based partly on the history of biodiversity management and partly on the distinction made between domestic and wild biodiversity, often leading to problems in coordinating, goal setting, planning and cooperation in comprehensive biodiversity management. As a result, the Action Plan recommended the institutionalization and establishment of an integrated biodiversity conservation program. This led to the establishment of the National Biodiversity Program (NBP) in 1998 headed by a Program Manager, and with two technical programs, namely the National Herbarium and the Agro-biodiversity Program.

In 1999, the Royal Botanical Garden was established under the NBP as an ex-situ plant conservation area and to commemorate the Silver Jubilee Celebration of the coronation of the 4th King, His Majesty Jigme Singye Wangchuck. Subsequently in 2001, the National Biodiversity Program was upgraded to the National Biodiversity Centre (NBC) as a non-departmental agency headed by a Program Director in order to strengthen conservation initiatives and coordinate biodiversity conservation and sustainable utilization programs in the country.

The Centre has developed a Vision 2030 as a living document to guide implementation of biodiversity conservation and sustainable utilization program in the country.

Buli Tsho, Zhemgang

1.3. Organizational Chart



VISION

Effective conservation, sustainable utilization and equitable sharing of benefits arising from access and use of biological resources.

GOAL

To become a premier institute on biodiversity in the country resulting in the effective management of biodiversity and maximizing the benefits from it as well as contributing to international efforts toward conserving biodiversity.

MISSION

Biological resources effectively conserved, sustainably used and benefits equitably shared for enhancement of livelihood, food security and environmental well-being of the country.

MANDATE

1. To coordinate biodiversity conservation and sustainable use programs in the country and implement where relevant/necessary.

2. To serve as a national biorepository for genetic resources, botanical collections, and collection of other biological resources.

3. To serve as the national focal agency to regulate access to and utilization of biological resources of the country, ensuring equitable sharing of the benefits arising from their access and utilization.

4. To serve as the national focal agency for bioprospecting and documentation of traditional knowledge associated with biological resources.

5. To coordinate formulation and implementation of policies and legal frameworks for conservation and sustainable use of biological resources.

6. To serve as the national clearing house and repository of biodiversity information of the country.

7. To provide specialized technical services related to conservation and sustainable utilization of biodiversity.

8. To provide taxonomic and systematics service on flora of Bhutan.

9. To promote education, awareness and participation in biodiversity conservation and sustainable use to enhance peoples' participation and leadership in conservation.

10. To coordinate and implement obligations under regional and international conventions, treaties and protocols related to biodiversity.

11. To promote national, regional and international institutional linkages and collaboration for technology transfer, technical capacity enhancement and collaborative research in the field of biodiversity.

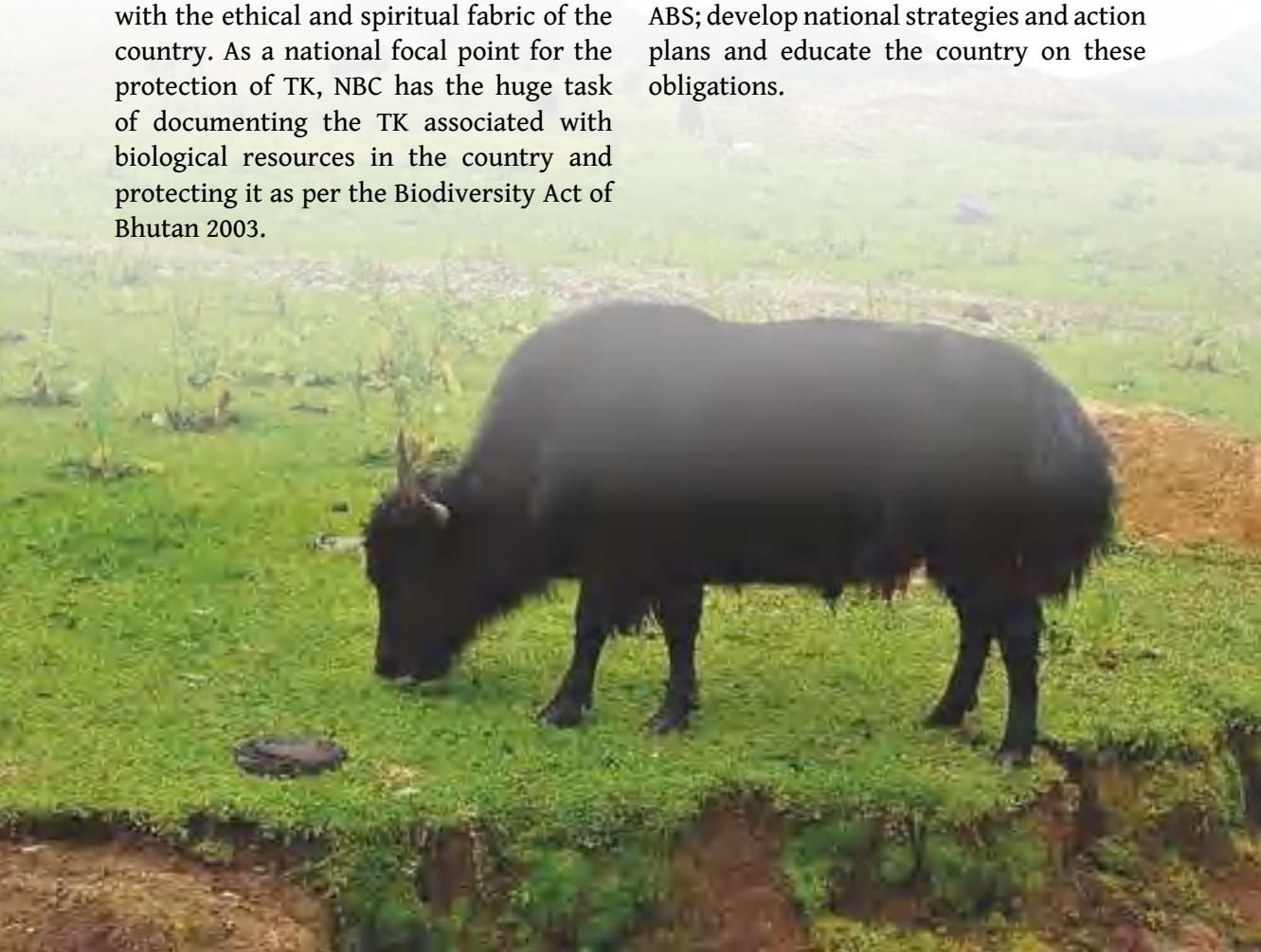
1.4. National & International Obligations

National:

NBC serves as the national focal point for ABS and TK associated with biological resources. It also houses the national portal on biodiversity. NBC is the focal agency leading the development of Biodiversity Action Plans/NBSAPs in the country. It is also the custodian of the Biodiversity Act of Bhutan 2003 and ABS Policy of Bhutan 2015. These responsibilities require the NBC to facilitate government and non-government ventures on biodiversity with the overall principles of ensuring fair and equitable sharing of benefits to the people and the country from the access to biological resources and also to ensure that such access does not contravene with the ethical and spiritual fabric of the country. As a national focal point for the protection of TK, NBC has the huge task of documenting the TK associated with biological resources in the country and protecting it as per the Biodiversity Act of Bhutan 2003.

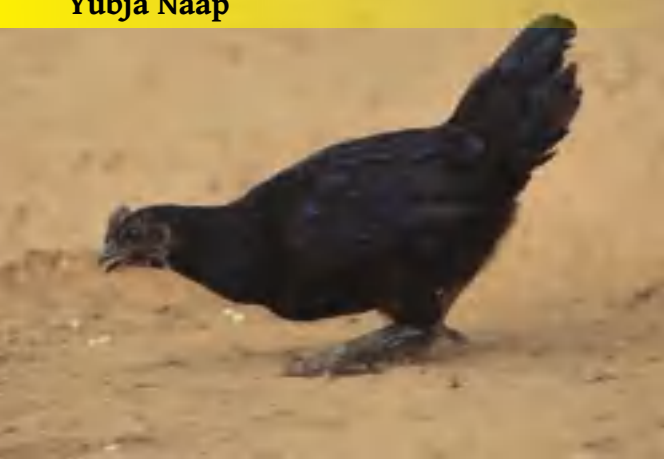
International:

NBC is the national focal point for the ITPGRFA, CGRFA, Nagoya Protocol on ABS, and the national nodal agency for the Global Biodiversity Information Facility (GBIF). Although NBC is not the National Focal Agency for CBD, it is the key national agency responsible for the implementation of the programs of work under this agreement. Such global obligations and requirements in addition to the country's own needs, require the NBC to strengthen national capacities and mechanisms and align our priorities along with the Global Plan of Actions on Plant and Animal Genetic Resources for Food and Agriculture (PAGR) as well as establish mechanisms on ABS; develop national strategies and action plans and educate the country on these obligations.

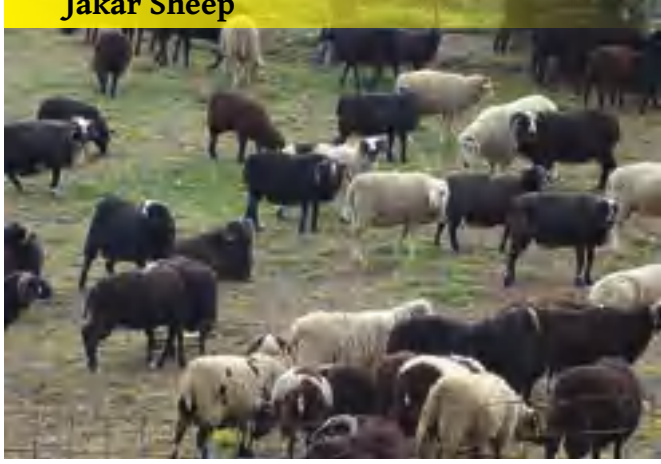


Hair sample collection from a yak.

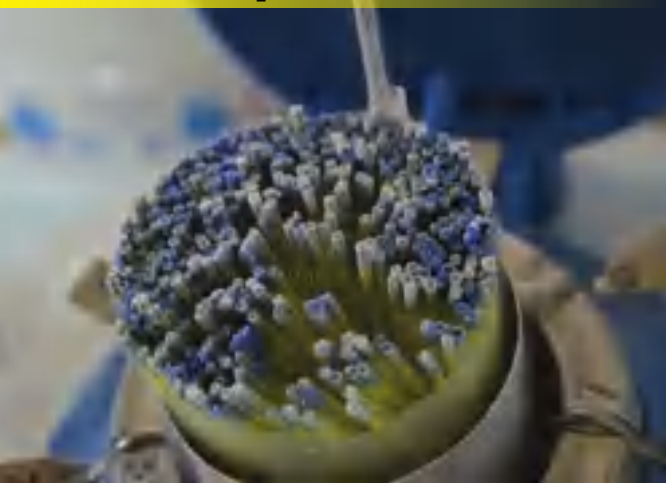
Yubja Naap



Jakar Sheep



Animal Germplasm in LN2



Embryos of Nublang

2. Animal Genetic Resources

2.1. In-situ conservation of animal genetic resources

Efforts have also been made to strengthen in-situ conservation activities for animal genetic resources supported by the Integrated Livestock and Crop Conservation Project (ILCCP) with capacity building and promotion of local diversity through value addition and establishment of the Nublang Conservation Fund in collaboration with the Department of Livestock. In addition, the program in collaboration with the various stakeholders is under process of establishing conservation communities for the other native livestock species. Funding is being sourced presently to formulate conservation strategies and implementation plans to strengthen in-situ conservation of animal genetic resources.

Achievements

As a part of our in-situ conservation program following activities were carried out:

a) Supplied 13 numbers (9 rams and 3 ewes) of Sakteng type sheep to National Small Ruminant Development Research Centre, Bumthang.

b) Supplied 104 numbers of native chickens to National Heifer and Native Poultry Breeding Centre, Sertsam, Lhuentse.

c) Supplied 10 numbers of native pig (Sapha) to a multiplier farmer in Zhemgang.

2.2. Ex-situ conservation of animal genetic resources at the National Animal Gene Bank

The animal genetic resources of Bhutan are unique and will remain central to rural livelihoods in many parts of the country. In order to conserve the genetic pool of the native animal breeds, the National Animal Gene Bank was established in 2005 in collaboration with the Centre of Genetic Resources of the Netherlands. The gene bank currently holds over 20,000 doses of semen and DNA samples from different indigenous livestock breeds for research, long term conservation and breed reconstruction in case of extinction. In addition to Semen cryopreservation and DNA banking, the program in collaboration with National Dairy Research and Development Center, Yesupang and National Nublang Breeding Center, Tashiyangphu under Department of Livestock, started embryo cryopreservation programs of important livestock species in the country, from 2018. Until now the joint activities collected and cryopreserved around 20 viable Nublang embryos. Characterization studies of production parameters and other useful economic traits are being studied through selective breeding and DNA mapping. The conserved germplasm will serve as a genetic pool for enhancing food security especially in the face of changing climate and other emerging threats.

Achievements

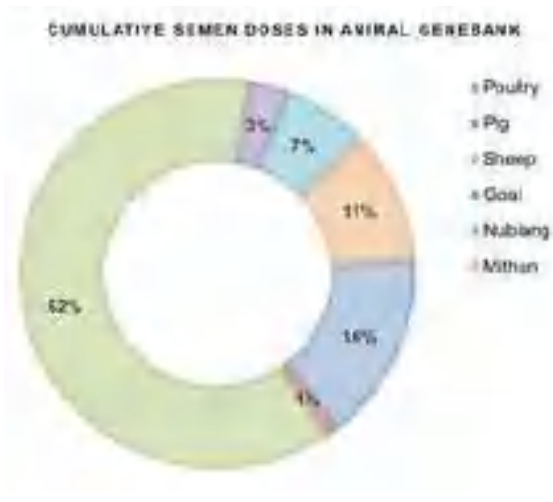
a) 2,027 doses of semen from four livestock species (Avian, Caprine, Ovine and Swine) collected and cryo-conserved.

b) 610 DNA samples were collected from different livestock species including Bhutanese Mastiff dogs.

Current Status

The animal gene bank collected and cryo-preserved more than 20,000 semen doses of different native livestock species; a brief overview of overall gene bank collection is presented in the following chart.

Boeta



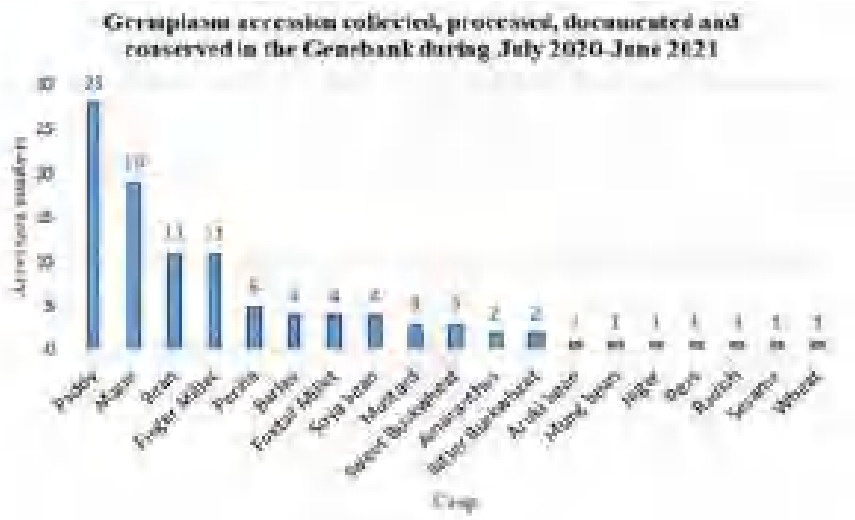
3. Plant Genetic Resources

3.1. Ex-situ conservation of crop genetic resources at the National Crop Gene Bank

To ensure that the crop genetic diversity or the plant genetic resources for food and agriculture (PGRFA) that underpin food supply are secure in the long term and serves as a source of germplasm for use by farmers, plant breeders and researchers for climate change adaptation, the National Crop Gene Bank was established in 2005 through the financial support of the Royal Government of the Netherlands under the Sustainable Development Agreement. Currently, it holds a total of 3,000 accessions of cereals, legumes, oil seeds and vegetables, however, the process of inventory, collection, characterization and documentation of germplasm from various agro-ecological zones of Bhutan is underway. In order to provide insurance against catastrophic loss of crop diversity being conserved at the National Crop Gene Bank, a "Safety Duplicate Gene Bank" has been established at the Agriculture and Research Development Centre Wengkhar (ARDC Wengkhar) in collaboration with ARDC Wengkhar in 2015. The duplicate accessions from the National Crop Gene Bank are being transferred to the Safety Duplicate Genbank as and when the new batch of accessions are ready to be transferred.

Achievements

Total of 103 crop germplasm comprising of paddy, maize, beans, finger millet, perilla, barley, foxtail millet, soya bean, mustard, sweet buckwheat, amaranthus, bitter buckwheat, azuki bean, mung bean, niger, peas, radish, sesame and wheat were collected, cleaned, assessed germplasm quality in terms of seed viability, equilibrium seed moisture percentage, germplasm purity, germplasm quantity, documented passport and management data and conserved in the Genebank.



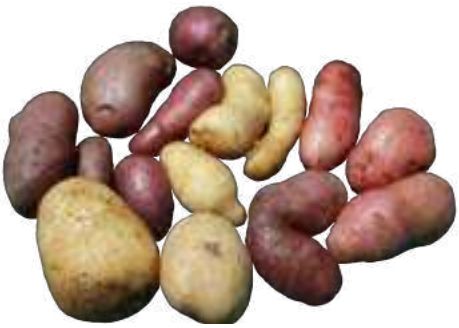
Agro-biodiversity inventory and germplasm collections were conducted in four Gewogs viz. Gangteng, Phobji, Silambi and Bongo during the financial year 2020 to 2021. Total of 10 species with 12 varieties of crops in the Gangteng Gewog, 10 species with 13 varieties in Phoji Gewog,11 species with 14 varieties in Silambi Gewog and 53 species with 75 varieties are being cultivated in Bongo Gewog.

Communities of Silambi gewog, Mongar.

Current Status

With this collection, cumulative of 2,950 accessions have been conserved in the Genebank consisting of cereals, legumes, vegetables, oil-seed crops, etc.

Living collections of 21 accessions of vegetatively propagated local crops consisting of 11 potato accessions, 7 garlic accessions and 3 onion accessions were grown, maintained and rejuvenated. Small samples of 7 accessions of beans and 5 accessions of chilli were multiplied and are being processed for conservation in the Genebank.



Potato germplasm collections rejuvenated & maintained.

Display of traditional cereals (Dru Na Gu).

3.2. On-farm conservation of crop genetic resources

The on-farm conservation program was initiated in 2001 through the support of the Biodiversity Use and Conservation in Asia Pacific (BUCAP) program in collaboration with the then RNR-RDCs and the Dzongkhag Agriculture Sectors. The program works with local communities in strengthening awareness and education on conservation and sustainable use of crop genetic resources with special focus on building the resilience of local communities to climate change. Till date, a total of about 2,000 farmers in 32 sites have been trained on conservation of genetic resources, promotion of local crops diversity through seed selection, seed purification, rehabilitation, broadening genetic base through Participatory Varietal Selection (PVS) and value addition through product development and diversification. Presently, two on-farm conservation projects are being implemented focusing on rice, beans and millets.

Achievements

The Evolutionary Plant Breeding (EPB) trials were introduced to Bhutan for the first time through the EPB project. The project is nationally coordinated by NBC and is implemented in collaboration with National Centre for Organic Agriculture, Yusipang, ARDCs Bajo and Samtenling, and Dzongkhag agriculture sectors of Paro, Punakha, Dagana, Tsirang and Sarpang. The trials focus on the development of evolutionary populations on rice and beans in the identified project sites. The evolutionary populations for both rice and beans were prepared by mixing most

Table 1. Crops, trial composition and experimental design under all the sites.

Dzongkhag	Site	Crops	Trial Composition	Experimental Design
Paro	Tsento Shari	Rice	5 varieties + 1 mixture	RCBD with 3 reps
Punakha	Kabjisa	Rice	6 varieties + 1 mixture	RCBD with 3 reps
Dagana	Tsangkha	Climbing beans	5 varieties + 1 mixture	RCBD with 3 reps
Dagana	Tsangkha	Dwarf beans	4 varieties + 1 mixture	RCBD with 3 reps
Tsirang	Mendrelgang	Rice	5 varieties + 1 mixture	RCBD with 3 reps
Tsirang	Mendrelgang	Climbing beans	5 varieties + 1 mixture	RCBD with 3 reps
Tsirang	Mendrelgang	Dwarf beans	4 varieties + 1 mixture	RCBD with 3 reps
Sarpang	Singgye	Rice	5 varieties + 1 mixture	RCBD with 3 reps

popular traditional and improved varieties collected and contributed by farmers and ARDCs from specific locations.

All the trials were designed as randomized complete blocks in rows and columns by using plots of 20m^2, where the rows corresponded in some locations to different terraces. The randomization was done with DiGGer, a program that generates efficient experimental designs with plots arranged in rows and columns.

Participatory assessment of the rice evolutionary populations.

Table 2: Rice varieties used for Evolutionary Plant Breeding trials.

	Sites			
	Tsento (Paro)	**Kabjisa (Punakha)**	**Mendrelgang (Tsirang)**	**Singgye (Sarpang)**
Materials/ Varieties	Khangma Maap	Dawa	Attey	Mansara
	Jakar Ray Naab	Dawa	Chottey Mashinu	Khamti
	Yusiray Maap 1	IR 64	Gawri Mashinu	Chottey Mashinu
	Yusiray Kaap 3	Bonday	Wengkhar Ray Kaap II	Bhur Kamja 1
	Dumbja	Nabja	IR 64	BhurRaykaap 2
	Mixture (Janam, Dumbja, Themja, Zhuchum, Shabja kuchum, and Hungrel Maap)	Tan-tshering	Mixture (Attey, Chottey Mashinu, Gawri Mashinu, Wengkhar Ray Kaap II and IR 64)	Mixture (Mansara, Khamti, Chottey Mashinu, Bhur Kamja 1 and Bhur Raykaap 2)
		Mixture (Dawa, Bajo Maap-1, IR 64, Bonday, Nabja and Tan-tshering)		

Evolutionary populations are either prepared by crossing or by mixing different improved and traditional varieties or landraces popularly grown in a particular agroecology. Farmers plant these mixtures in their fields which represents a specific micro-environment. Seeds are planted and harvested in mixtures and through natural crossing in crops, the genetic composition of the population harvested is continuously changing. Through this process the genotypes evolve in that environment are better adapted to the changing climate trends, local environment and farm conditions as compared to genotypes introduced from elsewhere which often takes several years to adapt to a new growing environment.

Through the process of natural selection combined with participatory selections using farmer's local knowledge and experiences, selections are made over time to ultimately identify a stable evolutionary population to be adopted by farmers for cultivation. The materials used for rice and beans trials under each site are presented in Table 2 and 3 respectively.

Table 3: Bean types and varieties used for EPB trials.

Sites		
Materials/ Varieties	**Tsangkha**	**Mendrelgang (Tsirang)**
Dwarf Bean	Gew Bori	Rajma
	Rajma Bean	Gew Bori
	Azuki	Azuki Bean
	Sheto Potharay	White dwarf Bean
	Mixture (Gew Bor, Rajma, Azuki, Sheto Potharay)	Mixture (Rajma, Gew Bori, Azuki Bean, White dwarf Bean)
Climbing Bean	Gew Bori	Gew Bori
	Kalo Gew Bori	Kalo Gew Bori
	Kanchi Bori	Pole Bean (white)
	Pilow Bori	Poole Bean (Grey)
	Pata Sanchum	Boshi Bori
	Boshi Bori	Mixture (Gew Bori, Kalo Gew Bori, Pole Bean (white), Poole Bean (Grey), Boshi Bori
	Mixture (Gew Bori, Kalo Gew Bori, Kanchi Bori, Pilow Bori, Pata Sanchum, Boshi Bori)	

In the rice trials, the data collection of the following traits such as: flowering date in days from sowing, days to maturity, blast score on a scale of 1-9, tillers numbers / hill from randomly selected hills, plant height in cm from 5 randomly selected plants , 1000 grain weight in gm, panicle length in cm from 5 randomly selected plants, moisture content, grain yield in kg per Hectare and number of grains per panicle were collected and submitted to the international expert at the project headquarters for data analysis. The expert will analyze the relationship between traits, entries and locations using genotype and genotype by environment (GGE) biplot and share the results.

Foxtail Millet participartory variety selection in Wangphu, Samdrup Jongkhar.

Finger Millet variety evaluation at Bongo, Chhukha.

Neglected and Underutilised Species (NUS) project status

The project is implemented in collaboration with the National Centre for Organic Agriculture (NCOA), Yusipang; Agriculture Research and Development Centers (ARDC) of Samtenling and Wengkhar; Dzongkhag (District) Agriculture Sectors of Chukha, Samtse, Samdrup Jongkhar and Tashi Yangtse; and farming communities of Bongo, Tading, Dorokha, Orong, Wangphu, Yalang and Bumdeling involving 403 direct project beneficiaries.

The project focuses on conservation and sustainable use of neglected and underutilized crops species that include three millet species namely, Finger millet (*Eleusine coracana*), Foxtail millet (*Seteria italica*) and little millet (*Panicum miliaceum*). Our farmers grow these crops in small pockets as an insurance against crop failures, for nutritional supplements, traditional and religious values and for saving seeds.

However, these crops are being marginalized and displaced due to various reasons, such as, limited attention from the research and development programs, lack of seed production and supply, poor awareness on the nutritional contents and manual and milling and processing techniques. Considering these issues and challenges, the project is focusing to improve management of and maintenance of these crops through value addition from seed diversification, seed quality improvement to postharvest processing techniques.

Table 4. The activities carried out during the Fiscal Year 2020-2021 under the NUS project.

Activity	Quantity and Quality	Project site
Participatory variety selection, evaluation and promotion of millets.	Participatory variety selection evaluation field trials initiated with 17 millet varieties in all the seven project sites.	Bongo, Tading, Dorokha, Orong, Wangphu, Yalang, Boomdelling.
Seed collection from the sites and evaluation at the Research and Development Centres.	13 varieties of finger millet are evaluated for seed purification at ARDC Samtenling.	ARDC Samtenling.
Seed exchange and introduction for promotion in the new site.	One finger millet variety collected from Boomdelling and distributed to other five sites and evaluated its performance.	Bongo, Tading, Dorokha, Orong, Wangphu.
Research on-station morphological characterization of millet varieties.	13 varieties of finger millet collected from the project sites and phenotypic characterization initiated at the Samtenling research and development centre. The activity will continue in the coming cropping season.	ARDC Samtenling.

4. Bioprospecting and Access & Benefit Sharing (ABS) Program

The Bioprospecting and ABS program was initiated in 2009 during the 10th FYP under the directive of the Ministry of Agriculture and Forests. It was established with the rationale to build national capacities to understand the value of Bhutan's biological resources and to explore measures to generate benefits from these resources. The program focuses mainly on biodiscovery research and ABS, and also facilitates the Material Transfer Agreements (MTA) as well as drafting and negotiating contract agreements on ABS.

A well-equipped bioprospecting laboratory and oil distillation facility for biodiscovery research has been established within the program and has built the capacity to conduct basic phytochemical analysis. The program also manages the Bhutan ABS Fund established as a plough-back funding mechanism to receive monetary benefits accrued from access to genetic resources or its associated traditional knowledge and support biodiversity conservation initiatives.

Current Status

A total of 12 ABS agreements have been successfully executed with national as well as the international users of genetic resources and its associated Traditional Knowledge (TK) which has resulted in the development of 11 nature-based products. Till date, around 279 MTAs have been facilitated and initiated a total of eight Community Based Natural Resources Management (CBNRM) groups to promote community leadership in conservation. The documentation of TK associated with biological resources has been completed in all the 205 Gewogs. Currently, the Bhutan ABS Fund has a total of Nu. 8.6 million generated from ABS initiatives.

Achievements

a) A first ever National Stakeholders' Consultation Meeting on the Traditional Knowledge associated with biological resources successfully organized. The meeting identified key agencies to lead different Traditional Knowledge.

b) Biodiversity Bill 2021 was presented to the Lhengye Zhungtshog. The Bill was introduced in the 5th Session of the third Parliament of Bhutan to be further reviewed by the Environment and Climate Change Committee of the National Assembly.

c) Standard Operating Procedure on the Bioprospecting collaboration successfully developed. The SOP has been presented to

Participants of the National Stakeholders' Meeting on Traditional Knowledge.

Introduced the Biodiversity Bill of Bhutan in the Parliament (Photo: Kuensel)

the 121st RNR GNHC and is being reviewed.

d) Inauguration of the Cold Press Oil Machine:

The operation of the cold press oil machine at the distillation facility of the Bioprospecting and Access and Benefit Sharing program, NBC, Serbithang was formally inaugurated by the Program Director, NBC.

The machine is first of its kind in the country and it will be used to extract fixed oils from potential seeds for bio-exploration. The informal ceremony was held to seek blessing for the successful operation of the machine and to mark the first extraction of *Prinsepia utilis* seed oil for its potential utilization in natural cosmetic and aromatherapy.

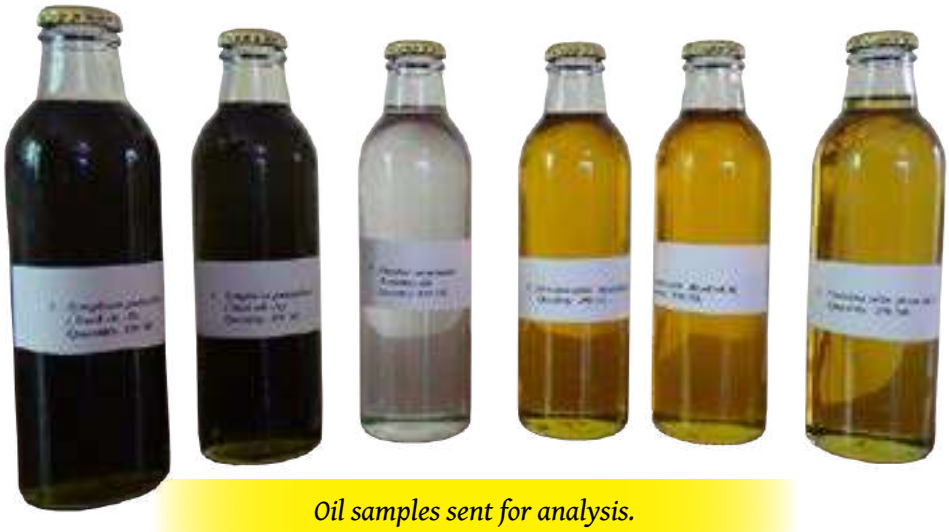
e) Actualization phase on *Swertia chirayita* with Chanel PB:

More than 2000 kgs of cultivated chirayita was sourced from local communities in Lauri gewog, Samdrup Jongkhar within the ABS framework. The materials was processed and sent to Chanel PB, France for the product development. The communities received premium price and other non-monetary benefits from

Inauguration of Oil Expeller

this initiative including some monetary benefits to the Bhutan ABS Fund for biodiversity conservation.

f) Analysis of oil samples for potential product development:
Samples of *Prinsepia utilis* oil has been shipped to Japan to explore its utilization in the natural cosmetics and aromatherapy. Further, analysis of seven different types of essential and fixed oils are being conducted at the Mitra S.K Pvt. Ltd., India to explore their potential utilisation.



Oil samples sent for analysis.

g) ABS product from *Oregano vulgure:*

Oregano vulgare has been sourced from Chumey gewog, Bumthang and Phobji gewog, Wangdue Phodrang with the engagement of the local communities. The plant has been researched for extraction of essential oil and a prototype has been successfully developed. The oil is currently being analysed for its utilisation in culinary, cosmetics, aromatherapy, etc., for exploration of markets under the ABS regime.

Oregano plant and its essential oil.

h) New scoping agreements are under negotiation with Bluezones group in Switzerland and Taisho Pharmaceuticals in Japan for biodiscovery research and product development.

i) 21 Material Transfer Agreements were executed to facilitate transfer of biological resources for academic and commercial research. Simultaneously, a follow up is being carried out for the submission of reports ensuing from the executed Material Transfer Agreements.

j) Sharing of benefits by ABS collaborators: A benefit sharing program was held at Dagala, Thimphu between Bio Bhutan (user of the biological resources) and the Jom Dagam Ngomen Tshogpa (providers of the biological resources).

Sharing of benefits to the Dagala community, Thimphu.

First ever National Stakeholders' Consultation Meeting on the Traditional Knowledge associated with biological resources organized.

The Biodiversity Bill was introduced in the 5th Session of the third Parliament of Bhutan.

Saxifraga flavida in its type habitat.

5. National Herbarium

The National Herbarium has been fully functional since 2003 with basic facilities in place through the support of the Danish Development Agency (DANIDA), with the main objective to house the botanical collections of the Flora of Bhutan project in the 1970s and to coordinate plant taxonomy related research and identify conservation priority species in the country.

Achievements

a) 2,627 species of plants were represented in the National Herbarium (THIM) out of 4,449 total species of vascular plants recorded to be found in the country. The estimated species gap was 1,822 species and for the 12th Five Year Plan, 25% of this gap was targeted i.e. about 500 species were expected to be collected and add 100 species annually to the collections at the National Herbarium.

While 101 species of plants were added each in the past two fiscal years, 104 species were added during the 2020 - 2021 fiscal year. Amongst the latest additions of 104 species, 12 are new records to Bhutan that were collected, documented and their botanical information made available at the National Herbarium.

12 species new to Bhutan documented and collected and the information made available at the National Herbarium.

***Saxifraga thiantha*, an endemic plant.**

Due to the increasing accessibility and the growing number of people interested in the plant taxonomy, the number of new species and new country records are increasing. While several native plants that were missed out in the Flora of Bhutan project are native, some of the plants are found to have been introduced either intentionally or unintentionally. Eight of the 12 new records are native while the remaining four are introduced or exotic plant species. The list of new records with their respective establishment means is provided in Table 5.

Table 5. List of plant species that are new to Bhutan.

Species	Family	Establishment Means
Jasminum ritchiei	Oleaceae	Native
Cestrum nocturnum	Solanaceae	Introduced
Canarium strictum	Burseraceae	Native
Rhaphiolepis bengalensis	Rosaceae	Native
Hemidesmus indicus	Apocynaceae	Native
Ipomoea campanulata	Convolvulaceae	Native
Manihot esculenta	Malvaceae	Cultivated/Introduced
Moneses uniflora	Ericaceae	Native
Persea fructifera	Lauraceae	Native
Sida urens	Malvaceae	Introduced
Silene latifolia	Caryophyllaceae	Introduced
Tetrastigma planicaule	Vitaceae	Native

b) Botanical collections at the National Herbarium: Total of 455 flowering plants, 38 ferns and 17 grass species were collected for the present fiscal year.

c) Eradication campaigns of invasive plant species:
Bhutan has several invasive plant species and some of them are among the world's worst ones. What is more unsettling is that these noxious plants are growing and spreading rapidly worldwide. Such invasive species are recognized as one of the major threats to biodiversity globally and they have negative impacts on nature, agriculture, livestock and human health. They out-compete and displace the native species causing change in the composition of the native plant communities, crop yield production is affected due to colonizing weeds while it could be hazardous to human health and animals as well. Increase in trade and travel and climate change are believed to be some of the factors contributing to introduction and spread of invasive alien plant species. Through the funding support of the Green Climate Fund (GCF) under the Bhutan for Life (BFL) scheme, the Centre is in the initial phase on the control measures. Whereas, the control management of invasive plant species in the country requires in-depth research, the species that require immediate actions and achievable are considered for control measures. Manual control of invasive plant species has been described as the best method considering population spread in small areas or landscapes. Recently, two species listed below are found to be growing in new locations for the first time which required immediate actions.

***Rhaphiolepis bengalensis*, a new record tree.**

i) Water hyacinth (*Eichhornia crassipes*), a serious aquatic weed originally from South America and listed amongst the world's 100 worst invasive alien species, is one of the least distributed invasive plant species in Bhutan. However, recently this plant has been found growing in a patch of wetland in Hesothangka at an elevation of 1226m. It was found that overflow from the wetland is directly discharged into Punatshangchu, thereby increasing the risk of the spread downstream of Punatshangchu and also its establishment in the shallow areas along the course of the river. This marshy plant was first documented from Gelephu in 1979.

Ipomoea campanulata

Manual removal - hand pulling, uprooting and drying of water hyacinth at Hesothangka, Wangduephodrang.

ii) Tithonia diversifolia, belonging to the Asteraceae family, is the native species of Mexico and South America. This plant has been widely introduced for ornamental purposes and escaped from cultivation to become invasive, mostly in disturbed sites, along roadsides and in ruderal areas near cultivation. Recorded for the first time from Samtse (2012) in Bhutan, it's also recorded from Sarpang, Samdrup Jongkhar and Chukha. In 2019, few individuals forming thickets were sighted from Sunkosh, Dagana which was deemed necessary for immediate removal considering its rate of spread. After its establishment it will be very difficult to eradicate through manual means and cost will be immensely high due to involvement of intensive labor. The species will proliferate rapidly and colonize the area forming thickets and prevent the growth of native plant species.

Current Status

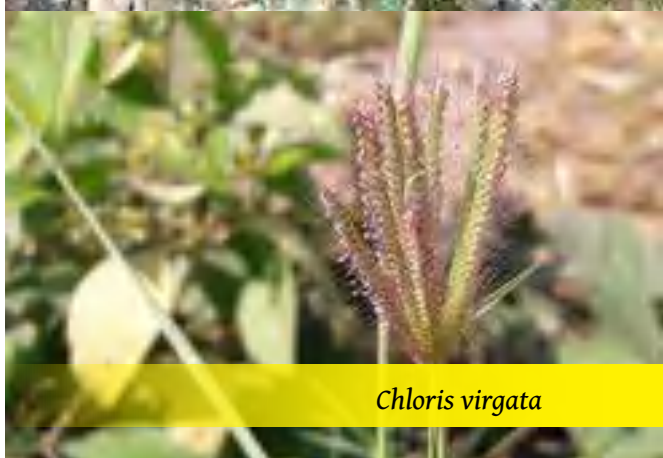
Currently, the herbarium houses over 20,000 collections of Angiosperms, Gymnosperms, Pteridophytes and Byrophytes including 300 collections of Insect Fungi. The list of species collected at the National Herbarium including ferns and grasses are listed at the Annexures 1, 2 and 3.

Slash and burn of Mexican sunflower (*Tithonia diversifolia*) at Sunkosh, Dagana.

Huperzia hamiltonii

Polystichum stimulans

Pennisetum flaccidum



Chloris virgata

6. Royal Botanical Garden Serbithang

The initial establishment of the Royal Botanic Garden in 1999 was facilitated through the funding support of BTFEC, where basic infrastructure of the garden was developed. Further, in order to implement activities to achieve its objective, BTFEC provided a 2nd phase grant amounting to Nu. 5.515 million from July 2001 to January 2004. Post-2004, the garden was mainly funded through the Royal Government of Bhutan (RGoB), with the exception of the Darwin Initiative project implemented from 2004-2006 to develop capacity of the staff and garden through a technical exchange program with Royal Botanic Gardens, Edinburgh.

The garden also carries out activities on the rescue and restoration of rare and threatened plant species. Recently, the garden has initiated tree-seed collections with support from the Royal Botanic Garden, Kew, UK for long term conservation of the woody plant diversity through plant conservation assessments, seed banking, seed longevity research and capacity building.

To serve as an educational resource and to create awareness on biodiversity conservation, the first of its kind Biodiversity Interpretation Centre has been established at the Garden with the support from the European Union (EU-SSP and EU-RDCCRP), UNDP and Botanic Gardens Conservation International (BGCI). The garden has been making significant contributions to the Royal Bhutan Flower Exhibitions and other national events.

Achievements

a) Contributed to the 113th National Day celebration at Punakha, 2020

Flowers raised for the National Day, 2020

The Royal Botanical Garden was one of the main stakeholders in the venue beautification at the Punakha Dzong for the celebration of the 113th National Day on 17th December, 2020. The Garden contributed about 5,000 annual flowers and decorative pots for the beautification works. The garden also contributed for the beautification works for the pur-threl (scattering of holy ashes) of his holiness the late Je Thrizur at the Punakha Dzong held on 7th November, 2020.

b) Sixth Royal Bhutan Flower Exhibition, Haa

Flowers raised for the Royal Bhutan Flower Exhibition

The 6th Royal Bhutan Flower Exhibition was held at Haa from 14th August, 2020. The exhibition was successfully held virtually in view of the COVID-19 pandemic and to bring the show to the people across the country. The Garden was one of the main stakeholders and produced about 15,000 flowers and green plants.

c) Inauguration of the Biodiversity Interpretation Centre

The Biodiversity Interpretation Centre was inaugurated by His Excellency Lyonpo Yeshey Penjor, Minister of Agriculture and Forests on 22nd May, 2021 coinciding with the International Biodiversity Day, and the Centre is dedicated to His Royal Highness Gyalsey Jigme Namgyel Wangchuck in commemoration of Gyalsey's fifth birthday. The Centre is open to the general public from Monday to Saturday.

d) Development of Fernery

The old polycarbonate house at the Royal Botanical Garden which remained underutilized has been renovated and developed into a fernery with displays of different fern collections. A total of 25 new fern species have been collected and planted at the newly developed fernery for fern diversity display.

Fern House

e) Native plant propagation facility (polycarbonate house) developed

The native plant propagation facility (polycarbonate house) was constructed and completed with funding support from EU-RDCCRP. The propagation facility will be used to initiate research trials on propagation and mass multiplication of native plants with potential for commercialization and restoration of threatened plants to the natural ecosystem. Saplings of native plants with commercial potential will be supplied to local communities to provide them an additional/alternative source of income and to build their resilience to the impacts of climate change on traditional farming systems and livelihood. Restoration of threatened plants to the natural ecosystem would support in restoring the diversity and resilience of the natural ecosystem. The facility with temperature control will also enable the garden to produce plants even in the cold winters which has not been possible till date due to the damage by frosts.

f) Orchidarium renovation

The old orchidarium at the garden was renovated with the funding support from EU-RDCCRP to protect the living orchid collections at the orchidarium. The transparent roofs were replaced with new transparent sheets and the old wooden windows were replaced with aluminum and glass panes. The renovated orchidarium lets in more sunlight for the orchids and helps in maintaining the temperature of the orchidarium.

Renovated roof of Orchid House.

g) Technical support for landscaping at Takila, Lhuentse.

The Royal Botanical Garden, Serbithang, joined the Ugyen Dongak Yoesel Chhoeling Monasery garden project team to provide technical support for landscaping and plantation of flowers. The landscaping consisted of the development of lawns, plantation of perennial flowers both at the inner and outside of the courtyard of the statue. The project covered a total area of 1.5 acres which were developed in lawns and planted with flowers.

h) International Day for Biological Diversity celebrated on 22nd May 2021.

Group photo with His Excellency Lyonpo Yeshey Penjor & UNDP Resident Representative Ms. Azusa Kubota

International Biodiversity Day (IBD) is a United Nations sanctioned international day to increase understanding and awareness of biodiversity issues. This year we celebrated the day on the theme "We are part of the solution". On this day the NationalBiodiversityCentre(NBC),Ministry of Agriculture and Forests inaugurated the Biodiversity Interpretation Centre at the Royal Botanical Garden Serbithang, which is a one-stop hub that provides an overview of Bhutan's biodiversity. The Bhutan Biodiversity Portal User Manual was also launched. The day was graced by His Excellency Lyonpo Yeshey Penjor and UNDP Resident Representative Ms. Azusa Kubota.

i) Floral diversity increased at the garden.

A total of 50 species (living and seeds), new to the garden were collected and planted at different thematic gardens such as the fernery, orchidarium, gene bank and the propagation unit for proper growth and care. The new collections will enhance the diversity of collections at the Royal Botanical Garden, Serbithang.

Current Status

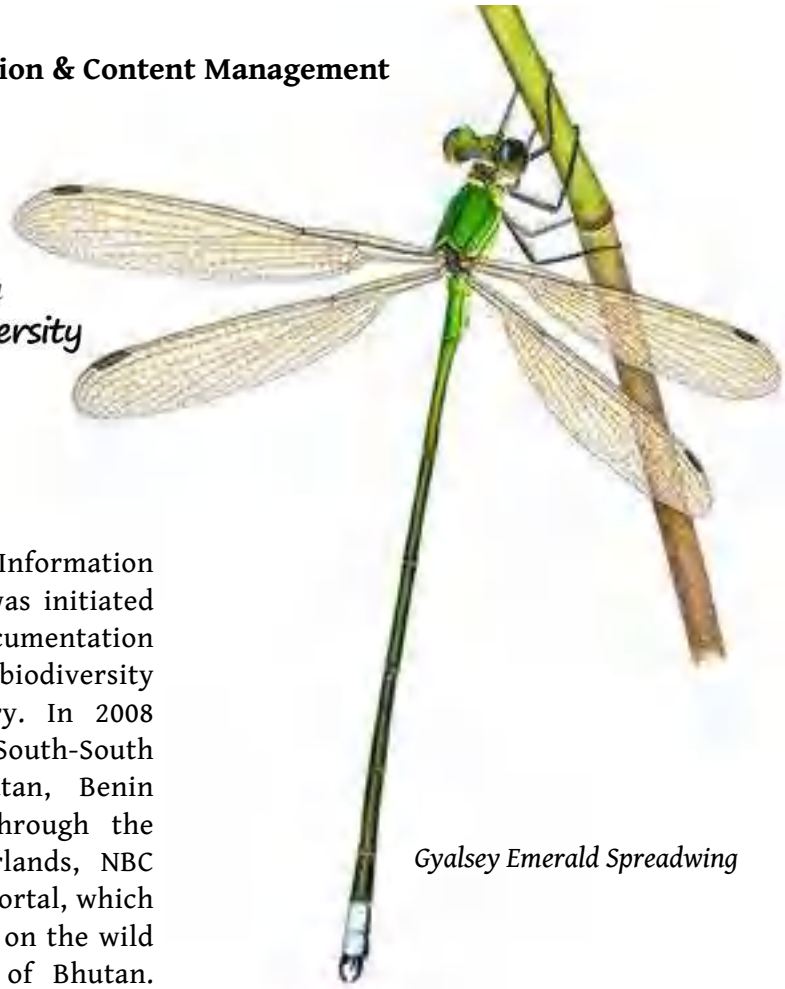
The garden currently holds a living collection of more than 800 native plant species which will be increased to 1000 species by the end of the 12th Five Year Plan. The garden is in the process of developing facilities accessible to peoples with disability (PwDs) in collaboration with the Zhenphen Group, SGP-UNDP and Disabled People's Organization under the "Nature For All" theme. The garden generated a revenue of Nu. 3,34,628/- through the sale of plants and visitor fee collections during this fiscal year.

50 plant species, new to the garden were added to enhance the diversity in the garden.

7. Biodiversity Information Management Program

7.1. Biodiversity Information & Content Management

Bhutan Biodiversity Portal



Gyalsey Emerald Spreadwing

The Biodiversity Information Management Program was initiated in 2003 to coordinate documentation and dissemination of biodiversity information of the country. In 2008 under the framework of South-South Cooperation between Bhutan, Benin and Costa Rica, funded through the government of the Netherlands, NBC developed the biodiversity portal, which currently holds information on the wild and domestic biodiversity of Bhutan. In 2010, the portal was upgraded into the national portal on biodiversity: the Bhutan Biodiversity Portal (www.biodiversity.bt).

Currently, efforts are underway to source funds to strengthen the portal as well as the coordination mechanism among the various biodiversity stakeholders to share biodiversity information. In 2019, Biodiversity Statistics of Bhutan was published, reporting the recorded number of species in the country for the first time. Since then, plans are underway to publish subsequent statistics on biodiversity. The program is the National Focal Point for the Biodiversity for Food and Agriculture under the Commission on Genetic Resources for Food and Agriculture (CGRFA). The program also coordinates the development and implementation of National Biodiversity Strategies and Action Plan (NBSAPs).

Achievements

a) Upgradation of the Bhutan Biodiversity Portal

The upgraded User Interface of the portal (Biodiv 3).

The Bhutan Biodiversity Portal (BBP) was upgraded from Version 2.0 to Version 3.0 (Biodiv 3). The upgraded version includes a new User Interface, which is more user friendly than the previous one. The Biodiv code base that powers the BBP has been redesigned to a microservices architecture where each microservices is independent with its code base and data store with integration by clear and well documented webservices to achieve the full functionality of the portal.

b) The program published 10 journal articles on plants and invertebrates of Bhutan.

c) More than 500 observations were recorded in the portal observed by more than 1,700 users for the fiscal year 2020-2021. More than 50 species pages were curated by the portal admins.

d) Awareness on the portal and biodiversity conservation were conducted for students of Royal Thimphu College (RTC), College of Natural Resources (CNR), Guide Association of Bhutan (GAB) and Bhutan Birdlife Society.

e) Bhutan Biodiversity Portal User Manual launched

The User Portal was launched by H.E. Lyonpo Yeshey Penjor with UNDP Resident Representative Ms. Azusa Kubota; Director of Livestock, Dr. Tashi Y. Dorji; and Program Director of NBC, Dr. Karma Dema Dorji (Photo: ICTD, MoAF)

The Bhutan Biodiversity Portal User Manual was launched on 22nd May 2021 coinciding with the International Day for Biological Diversity. The user manual is expected to provide a step-by-step guidance to use the portal while uploading and downloading the biodiversity information and datasets. The portal provides platform to document biodiversity information which include species photos, videos, documents, audios and datasets related to Bhutan's biodiversity.

f) Release of a New Version of the Portal App

A new version of the Bhutan Biodiversity Portal Application (Progressive Web Application) has been released based on the upgraded Portal web page (Biodiv. 3).

Current Status

Currently, there are more than 1,700 registered users on the BBP and they have contributed a total of 65,525 observations, more than 200 documents and more than 20 datasets related to the country's biodiversity. A new specimen feature in the Portal is currently under development.

7.2. National Invertebrate Repository

The Invertebrate Collection Repository was established in 2017 to coordinate the collection and documentation of invertebrates including insects among the various relevant stakeholders. Since the inception, many new species discoveries such as Gyalsey Emerald Spreadwing (dragonfly), *Truncatellina bhutanensis* (one of the world's smallest snails), etc were made. Numerous journals and field guides were published. The repository was initially funded by BTFEC with technical support from the Naturalis Biodiversity Center, The Netherlands.

Current Status

Currently, the repository has more than 25,000 collections of invertebrates. The collection of snails, bees and wasps, and moths and documentation are still on-going. However, some taxa group collections are being coordinated by various institutions such as the collection of lady beetles coordinated by the College of Natural Resources and National Plant Protection Centre, moths by Ugyen Wangchuck Institute for Conservation and Environmental Research, etc.

Achievements

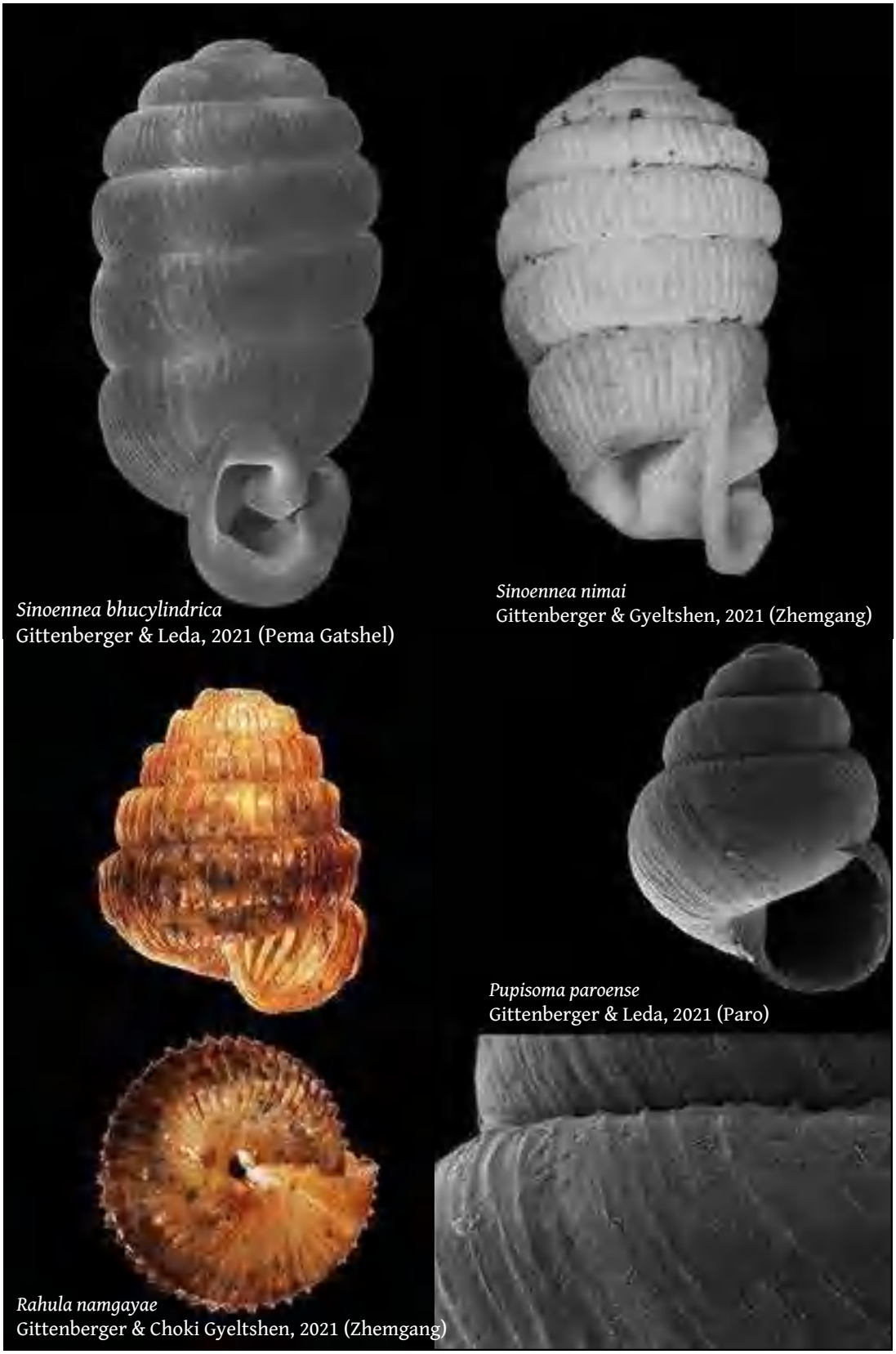
a) Collected a total of 46 species of snails from Haa, Chhukha and Bumthang regions and are deposited at the National Invertebrate Repository.

b) Collected a total of 23 species of bees and wasps from Bumthang region and processed.

c) Discovery of 12 species new to science in the fiscal year 2020-2021

Chiloschista densiflora
Gyeltshen, C.Gyeltshen & Dalstrom, 2020
(Zhemgang)

Chiloschista himalaica
Tobgay, C.Gyeltshen & Dalstrom, 2020
(Chhukha)



Sinoennea bhucylindrica
Gittenberger & Leda, 2021 (Pema Gatshel)

Sinoennea nimai
Gittenberger & Gyeltshen, 2021 (Zhemgang)

Pupisoma paroense
Gittenberger & Leda, 2021 (Paro)

Rahula namgayae
Gittenberger & Choki Gyeltshen, 2021 (Zhemgang)

Pseudonapaeus occibhutanus
Gittenberger, Gyeltshen & Sherub, 2021 (Paro)

Laevozebrinus parvus
Gittenberger, Gyeltshen & Leda, 2021
(Chhukha)

Erhaia jannei
Gittenberger & Stelbrink, 2020 (Thimphu)

Erhaia pelkiae
Gittenberger & Gyeltshen, 2020 (Thimphu)

Philalanka bhutana
Gittenberger & Gyeltshen, 2021 (Zhemgang)

Sculpteuconulus obliquistriatus
Gittenberger, Gyeltshen & Sherub, 2021
(Trongsa, P/Gatshel, Gasa)

8. Annual Performance Agreement (APA) 2020 – 2021

Objective: To enhance management of natural resources for sustainable utilization of ecosystem goods and services.

Table 6. Success Indicators, Targets and Achievements for APA 2020 - 2021.

Action	Success Indicator	Unit	Weight	Target	Achievement
Enhance conservation and sustainable utilization of biological resources	No. of accessions of crop germplasm conserved in plant genebank	Nos.	3	100	A total of 103 accessions collected and processed at the National Crop Gene Bank.
	Access and benefit sharing initiatives developed	Nos.	3	1	Essential oil from Oregano plant species developed. The Oregano species were collected from Phobjikha, Wangdue Phodrang and Bumthang.
	No. of doses (semen) of animal germplasm conserved in animal genebank	No. of doses	3	1000	A total of 2027 semen collected and processed for chicken, sheep, goat, and pig.
	Animal germplasm (DNA) of domestic animal breeds in animal genebank	No. of DNA	3	600	A total number of 610 DNA collected and processed for chicken (172), mastiff (canine) (50), goat (caprine) (35), sheep (ovine) (154), cattle (bovine) (76), and pig (swine) (123).
	Diversity of biological resources conserved	No. of species	3	27	A total of 142 species (Live plants and seeds) were collected (50 species new to Royal Botanical Garden).
Community engaged in biological resources conservation	On-farm conservation and sustainable utilization of biological resources promoted	Nos.	2	1	The activity for on-farm millet conservation is completed for Bomdeling, Yalang, Wangphu and Orong gewogs.
Generate biodiversity information and improve access	Botanical information generated and access improved	Nos.	3	100	A total of 104 species were collected and processed at the National Herbarium and documented.

Table 7. Trend values of Success Indicators for 12th Five Year Plan.

Success Indicator	Unit	Actual Values [FY 2018-19]	Target Values [FY 2019-20]	Projected Values [FY 2020-21]	Projected Values [FY 2021-22]	Projected Values [FY 2022-23]
No. of accessions of crop germplasm	Nos.	100	100	100	100	100
Access and benefit sharing initiatives developed	Nos.	1	1	1	1	1
No. of doses (semen) of animal germplasm	No. of doses	1000	1000	1000	1000	1000
Animal germplasm (DNA) of domestic animal breeds in animal genebank	No. of DNA	600	600	600	600	600
Diversity of biological resources conserved	No. of species	27	27	27	27	27
On-farm conservation and Sustainable utilization of biological resources promoted	Nos.		1	1		1
Botanical information accessible for new additional collections	Nos.	100	100	100	100	100

9. Budget Outlay for the Fiscal Year 2020 – 2021

Table 8. Budget outlay for National Biodiversity Centre (in millions).

Budget (Nu.)			Funding		
Current	*Capital*	*Total*	*RGoB*	*External*	*Total*
24.112	25.797	49.909	31.173	18.736	49.909

10. Biodiversity Overview Articles

The development of the Bhutan Biodiversity Portal

Choki Gyeltshen, Reena Gurung & Karma Dema Dorji

The Bhutan Biodiversity Portal was developed as the first of its kind for South Asia - a pioneer initiative, established and guided by a consortium of major biodiversity stakeholders, with technical support from an external collaborator.

The project agreement was initiated under the framework of the UN Conference on Environment and Development (1992) in Rio de Janeiro, Brazil. This agreement was formalised in 1994 and subsequent programmes led to the creation of the Bhutan Integrated Biodiversity Information System (BIBIS) in 2002. BIBIS was the product of a collaborative effort between many agencies and aimed to create a biodiversity information platform that is accessible to anyone interested in Bhutan's biological resources.

In 2008, BIBIS was upgraded to a web-based biodiversity portal and in 2011; it was further advanced to its present form: the Bhutan Biodiversity Portal (BBP), a national consortium-based, citizen science approach to documenting and managing biodiversity. Consortium members include the Royal University of Bhutan represented by the College of Natural Resources, Department of Forests and Park Services represented by Nature Conservation Division, and Ugyen Wangchuck Institute for Conservation and Environmental Research; Information, Communication and Technology Division of the Ministry of Agriculture and Forests; World Wide Fund for Nature – Bhutan; and the National Biodiversity Centre which acts as the secretariat for the consortium. Technical support is provided by Strand Life Sciences based in Bangaluru, India.

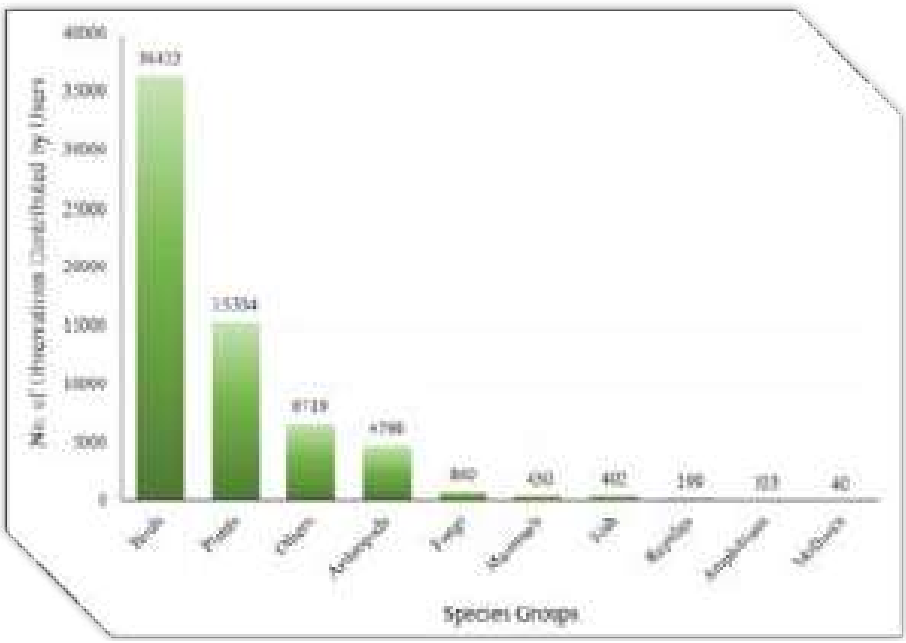


Fig. 1. Number of observations by species groups contributed by registered users until 30th June 2021.

This citizen science initiative aims to promote and harness collective effort in generating and verifying content in a comprehensive, cost-effective and inclusive manner, thereby alleviating the monumental task of documenting the rich biodiversity of Bhutan. Additionally, having a consortium of different biodiversity stakeholders helps address the issue of duplicative efforts in developing and managing isolated information systems and databases around the country. Dickinson, Zuckerberg and Bonter (2010) suggest that this model of citizen science: the monitoring of biodiversity across large geographic regions has been highly influential in the field of ecology. They also argue that multiple species surveillance across an area has the potential to shed light on unexpected or counterintuitive trends that could provide a valuable trigger for more systematic, targeted ecological research.

The BBP was officially launched in December 2013 and since then; it has been gaining momentum with steady increases in the numbers of observations and registered members. Currently, there are more than 1,700 registered users on the BBP and they have contributed a total of 65,525 observations, more than 200 documents and more than 20 datasets related to the country's biodiversity (Fig. 1). All data on the portal are open-access and shared under the Creative Commons licensing system. The users upload observations of plant or animal species in the form of photos, video or audio files. They also specify the date and location of their observation and can request assistance from other members of the portal with species identification. The portal contains a wide range of reference material such as species information (curated and detailed description of individual species found in Bhutan); maps (Fig. 2); datasets of specific

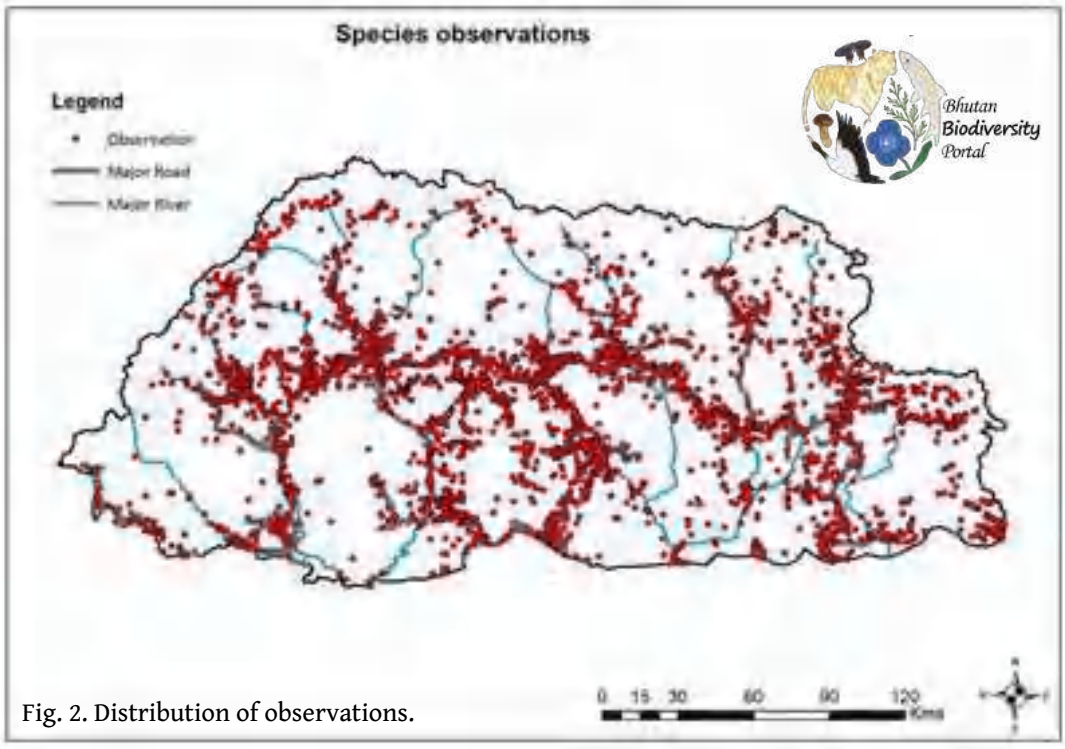


Fig. 2. Distribution of observations.

taxonomic groups, for example a checklist of fish species found in Bhutan; as well as journal articles and other literature related to local biodiversity.

A primary objective of this portal is its accessibility to all sections of society: students, researchers, policy makers, amateur naturalists, tourism operators, journalists, and anybody with an interest in Bhutan's flora and fauna. Our collective efforts will ensure that we (a) understand and appreciate our rich biodiversity, (b) translate this understanding into effective conservation and sustainable use, and (c) respect the principle of intergenerational equity and our sacred duty as custodians to uphold, protect and deliver intact our 'green heritage' to future generations.

Through citizen science, many new discoveries are made. One such example is the rediscovery of *Primula jigmedeana* after 87 years by Mr. Tez Ghalley at Bumdeling Wildlife Sanctuary, Trashi Yangtse (Fig. 3; BBP, 2021). *Primula jigmedeana* W.W.Sm is a special plant in the history of Bhutan as it was discovered by George Sherriff and Frank Ludlow in 1933 and named honoring the Second King of Bhutan, His Majesty Jigme Wangchuck.

Fig. 3. *Primula jigmedeana,* observed by one of the member of the portal, Mr. Tez Ghalley at Bumdeling Wildlife Sanctuary, Trashi Yangtse on 18th July 2020 (Photo: Tez Ghalley).

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Sharing of Benefits by the Bio Bhutan Pvt. Limited to Jom Dagam Ngomen Tshogpa, Dagala, Thimphu under the Access & Benefit Sharing (ABS) Framework

Karma Dema Dorji, Chencho Dorji & Mani Prasad Nirola

A benefit sharing ceremony between the Bio Bhutan Pvt. Limited and the Jom Dagam Ngomen Tshogpa, a community-based group in Dagala under Thimphu was held on 11th May 2021 at Dagala Gewog in presence of the National Biodiversity Centre (NBC), MoAF, the national focal agency for the implementation of the ABS regime in Bhutan.

The Bio Bhutan Pvt. Ltd. and NBC with support from the UNDP-GEF Nagoya Protocol Implementation Fund (NPIF) project "Promoting the Application of the Nagoya Protocol on Access to Genetic Resources and Benefit Sharing in Bhutan" had implemented the ABS scheme with the Jom Dagam Ngomen Tshogpa. The Bio Bhutan Pvt. Limited has been granted access to leaves of the *Rhododendron anthopogon* (Balu) for the production of Drizang perfume, Tshalung massage oil and a natural handmade soap based on the mutually agreed terms and conditions through negotiations and execution of an ABS agreement on 21st June 2017. This ABS scheme is a tripartite (Government - Private Company - Local Community) ABS agreement.

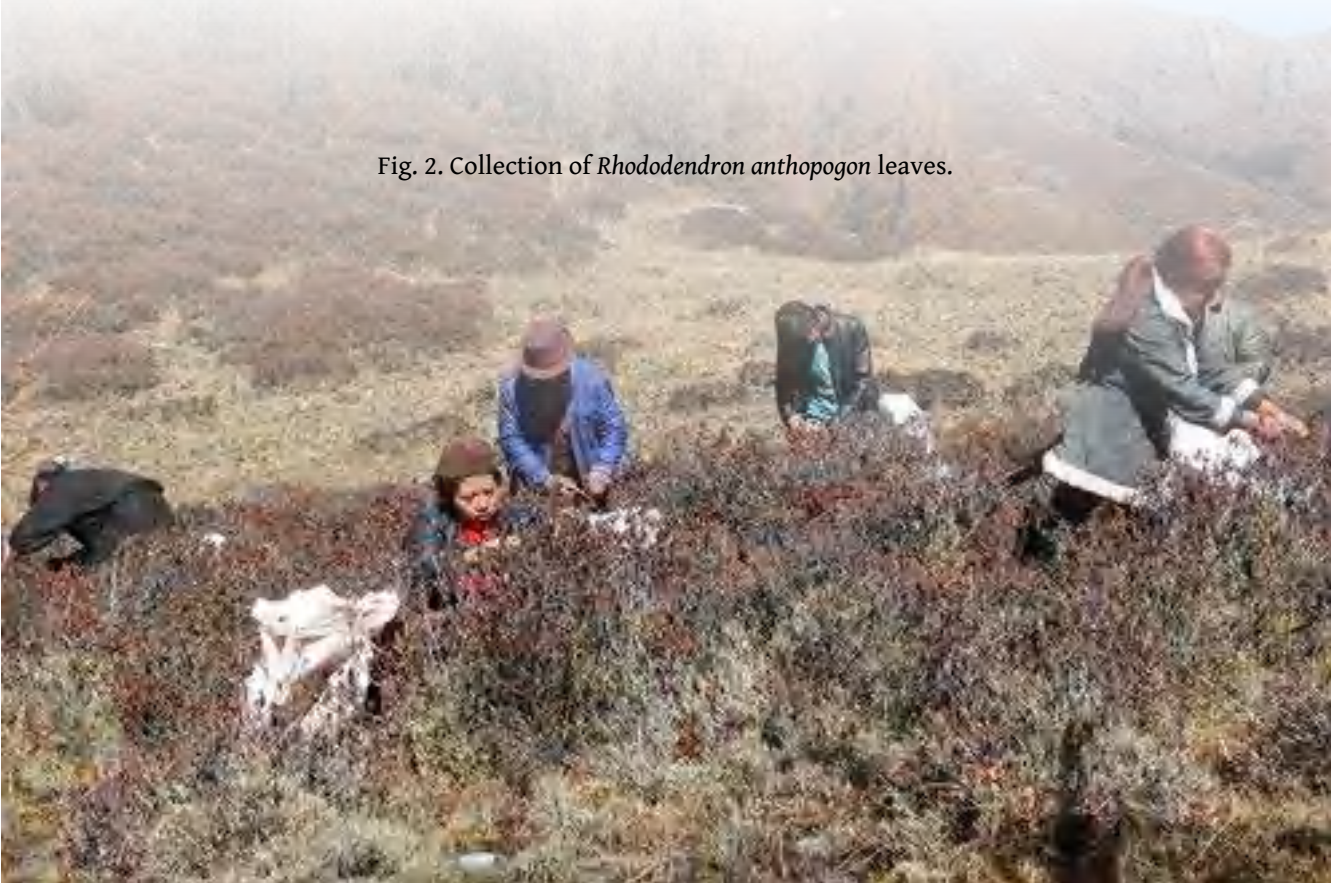
As per the terms and conditions of the ABS agreement, the Bio Bhutan Pvt. Limited agreed to share 7% of the profit to the Jom Dagam Ngomen Tshogpa annually from the

Fig. 1. Products from the initiatives.

sale of the products developed from the *R. anthopogon* leaves. Further, an agreement was reached to share 2% of the profit to the Bhutan Access and Benefit Sharing (BABS) Fund as a symbolic contribution by the company and the local community to support biodiversity conservation and sustainable initiatives in the country. A cheque amounting to Nu. 19,374.49 was handed over to the chairman of the group as a benefit for the year 2018-2020, while Nu. 5,535.50 was deposited into the BABS Fund. In addition to receipt of the profit, one each of the products was handed over to the office-bearer of the group to be shared with the rest of the members of the group as the gathering of all the members was discouraged to uphold COVID-19 restrictions. In addition to the above, the group also received other benefits in the past which included the payment of the premium price for raw materials, harvesting tools and the sustainable harvesting capacity building training. Although the amount received by the community may be small in the beginning and because business have been impacted by the COVID-19 pandemic, it is going to be substantial in the coming years as the products capture a better market.

The main objective of supporting such ABS initiatives is to create a platform for the enhancement of livelihoods of the local communities and promote the participation and leadership of the local communities in the conservation of biological diversity, their sustainable utilization as well as adopt ABS principles by the partners involved under the ABS agreement. Bhutan being one of the biodiverse rich countries, has the potential to tap benefits from biodiscovery research engaging local communities and companies creating a niche market for the nature-based products in the national as well as international market.

Fig. 2. Collection of *Rhododendron anthopogon* leaves.



Alternate Livelihood Opportunity for Farmers of Dzedokha Village, Loggchina through Access & Benefit Sharing Initiative

Chencho Dorji, Mani Prasad Nirola, Leki Wangchuk & Jamyang Choden

Local community of Dzedokha, one of the remote villages in Loggchina Gewog in Chhukha has been engaged in the cultivation of *Zingiber cassumunar* locally known as 'Phacheng' and the production of Zhinor massage balm and liniment oil accessing its traditional knowledge for the last five years. This particular plant is known for its anti-inflammatory properties and local people have always used it to cure joint and muscle pains for generations. With support from the National Biodiversity Centre (NBC) through the GEF-UNDP funded project-Nagoya Protocol Implementation Fund (NPIF) and the GEF-UNDP Small Grants Programme, the capacities of the members of the Dzedokha Phancheng Detshen has been built from the cultivation of *Z. cassumunar* (Fig.1) and undertake development of trademarked Zhinor products. Currently, the Zhinor products (Fig. 3) are being sold in the national markets and doing quite well to establish its market. The organic certification has also been granted for the cultivation of organic zingiber.

Fig. 1. (L) *Zingiber cassumunar* (R) Loading of the *Zingiber cassumunar.*

'Phacheng' is now a household name not only in Dzedokha village but also in neighboring villages of Loggchina and Phuentsholing Gewog and has become an additional source of income to the local people who mostly depended on cash crops like ginger, cardamom and oranges. With a volatile ginger market and decline of cardamom and orange harvest over the years, zingiber project has become a new ray of hope to the people of Dzedokha and some farmers have started to earn as high as Nu. 50,000-80,000 annually from the sale of zingiber rhizome.

With an objective to further enhance local livelihoods, generate employment opportunities and promote local entrepreneurship, a 'Natural Product Development Facility' has also been established at the Dzedokha village to be operated as a social enterprise. The identified operators from the Dzedokha Phacheng Detshen (Fig. 2) have been extensively trained and are competent for the development of the Zhinor line of products.

The operators will buy zingiber rhizome from members of the community and extract the essential oil for the development of Zhinor products. The operators will share a certain percentage of the proceeds from the sale of the products to the community group as a benefit of the community group. NBC will continue to provide a role of hand- holding and offer technical support to the operators of the facility until they are capable of operating the social enterprise by themselves.

In the long run, this initiative is expected to generate employment opportunities for the unemployed youths in the village as well as increase livelihood and strengthen community vitality. It is based on the vision to perpetuate the equitable sharing of benefits through access of genetic resources and its associated traditional knowledge within the country and such genetic traits of the plant is carefully sustained and preserved in time to come. It is also with a goal to enhance the sustenance of farmers through value addition and income diversification as well as to empower local communities.

Fig. 2. Processing of zingiber oil.

Fig. 3. Community displaying the zingiber products.

Inventory & Documentation of Traditional Knowledge & Systems related to the Biodiversity Conservation & Climate Resilience

Mani Prasad Nirola, Chencho Dorji, Leki Wangchuk,
Jamyang Choden & Pema Lhamo

The National Biodiversity Centre through the funding support from the 'Bhutan for Life' project has carried out the Inventory and Documentation of Traditional Knowledge and Systems related to the Biodiversity Conservation and Climate Resilience in the gewogs/local communities that fall under the Protected Areas System (National Parks and Wildlife Sanctuaries) from January 2019 to March 2021. The primary objective of the study was to document traditional knowledge and systems related to climate resilience and biodiversity conservation, and assess and promote the use of traditional knowledge and systems through policies and strategies in conservation and climate resilience intervention. The secondary objectives were to understand the perception of the local communities on climate change and its impacts, understand the types of farming systems and how it has evolved over time and correlate it with climate change, understand the discourse of human-wildlife coexistence and management, etc.

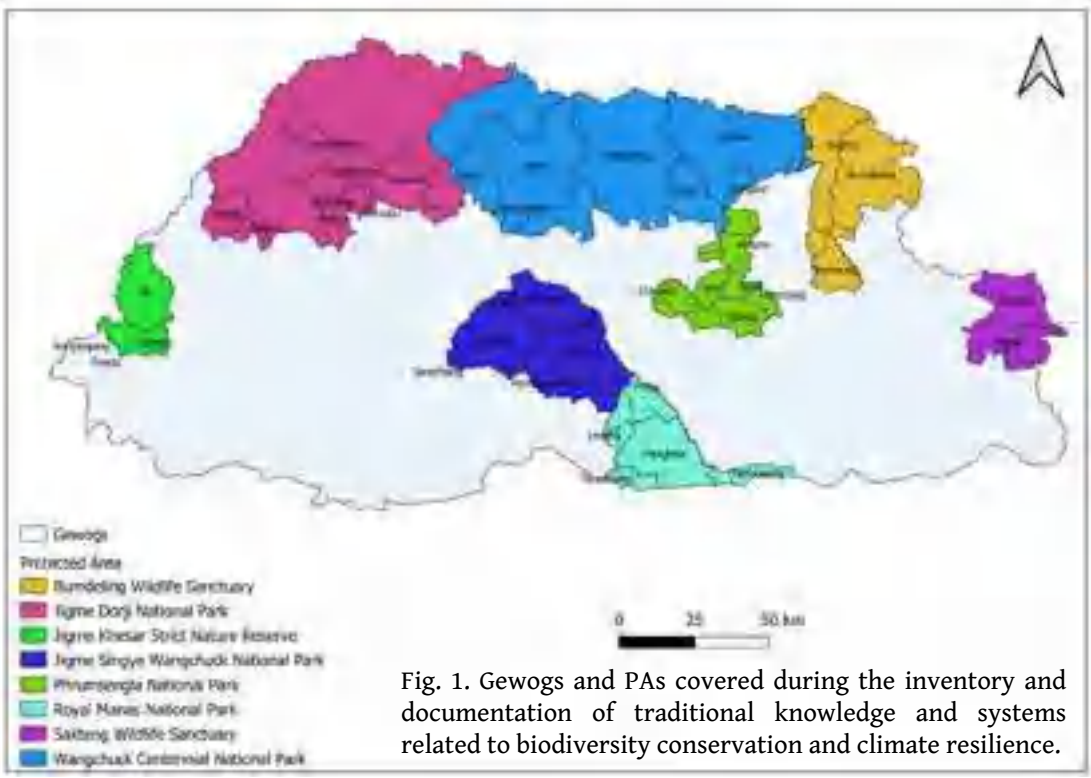


Fig. 1. Gewogs and PAs covered during the inventory and documentation of traditional knowledge and systems related to biodiversity conservation and climate resilience.

Fig. 2. Participants from Norgaygang and Tendu gewogs during the community consultation and awareness meeting at Tendu gewog, Samtse.

From January 2019 to March 2021, the inventory and documentation of TK and systems was carried out in 43 Gewogs in 16 Dzongkhags under the jurisdiction of eight Protected Areas (Fig. 1). A total of 361 participants attended the community consultation and awareness meeting, of which 290 were male and 71 were female. Through the consultation and awareness meeting, 254 participants were identified for the focused group meeting and the interview to document the traditional knowledge and systems. Out of 254 participants, 206 were male and 48 were female (Fig. 2).

It was evident from the study that the local communities possess rich traditional knowledge and systems related to farming systems, natural resource management, watershed management, soil, land and nutrient management, pest and disease management, human-wildlife coexistence, etc. However, a lot of these knowledge and systems have been eroded or lost due to non-use and socioeconomic development. It was evident that the traditional and local beliefs promoted the conservation of the biodiversity in the country. Various key ecological areas were recognized and conserved as the abodes of gods, goddesses, protective deities and mountain, river, forest and underworld spirits. Examples are: Ney, Neydo, Neysing, Neypo, Neydak, Zhidak, Tsan, Sadag, Keylha, Yuelha, Lu, Dud, Devithan, etc. The systems like Reedum, Ladum, Sokdum etc., were very effective in managing the conservation and sustainable utilization of natural resources in the past. Traditional systems of forest and nature management such as Reesup, Meesup, Shingsungpa/Thogsup, Chusup/Chupon, etc., were so effective in the past. However, these systems are not put into practice these days. It was highlighted in the study that these systems faded away after the enactment of Forest and Nature Conservation Act 1995 and Land Act 2007. Various rituals like Karchoe, Benchoe and Marchoe are being performed to prohibit the sacrifice of animals. Other rituals such as Jensoe, Rew Sangchoe, Devi Puja, Rowa Khe, Sansari Puja, etc., are performed to pay respect to the local

deities. These different systems have directly or indirectly been contributing to the maintenance of rich biodiversity of the country but as Bhutan is undergoing rapid and dramatic socioeconomic development, these knowledge and systems have eroded and are also fading at an enormous pace. Documentation of these knowledge and systems and mainstreaming it into the policy is considered to be of paramount importance (Fig. 3). It was also evident from the study that there are no legal rights to sacred places, abodes, grooves etc. in Bhutan. As a result, it doesn't give local communities power and authority to conserve these areas with cultural, environmental and spiritual significance. Therefore, a legal and policy framework, which blends traditional systems with modern conservation policies, is recommended to affirm, uphold and strengthen conservation programs in the country.

Fig. 3. Focused group meeting and interview to document traditional knowledge and systems related to biodiversity conservation and climate resilience at Athang Gewog, Wangduephodrang.

Rhododendron pogonophyllum Rediscovered in Bhutan after 84 years

Phuentsho, Nima Gyeltshen, Kencho Dorji, Rinchen Dorji,
Kezang Tobgay & Sampa

The Flora of Bhutan describes a total of 46 species out of which 45 are known to be occurring in Bhutan. The book describes *Rhododendron pogonophyllum* Cowan & Davidian as a rare endemic plant to Bhutan. Subsequent publication of the book "Plants Endemic to Bhutan Himalaya" by the NBC published in 2015 listed it as one of the endemic plant species found in the country with a herbarium specimen as an evidence.

"Wild Rhododendrons of Bhutan," a book by Rebecca Pradhan in 1999 has photos of the Rhododendrons found in Bhutan including *R. pogonophyllum* with descriptions of its flower, leaf, flowering time, habitat, altitude, distribution and with a remark stating as an endemic and rare plant species not seen since 1937, but without any picture. The book reports a total of 46 Rhododendron species in Bhutan.

R. pogonophyllum was first collected by George Sherriff, a Scottish plant collector on 7th June 1937 at Tang Chu in Wangdue. His 1937 trip was mainly focused around the central Bhutanese mountains including the Black Mountain range. He ventured out to explore the Pele La range which falls to the east of Dangchu which Sherriff wrote as Tangchu in his specimen locations.

After a night halt at Trashidinkha in Dangchu, he climbed towards Kyitsugang which Sherriff wrote as Chizukang. On his second day, he found many interesting plants including *Primulas* and the *R. pogonophyllum* in particular under the collection number 3216. Earlier the specimen collected was thought to be *Rhododendron hypenanthum* which is now considered as a subspecies of *Rhododendron anthopogon*.

Fig. 1. Exploring *Rhododendron pogonophyllum* in Kyitsugang, Dangchu, 2021.

Later Cowan & Davidian described it as a new species using the specimen collected by Sherriff from this locality and the specimen currently resides at the Royal Botanic Garden, Edinburgh in UK with the catalogue number E00010309. Later in July Sheriff also collected the same Rhododendron species from Rinchen Chu (Chore) in central Bhutan on 13th July 1937.

Currently, Chore is known as Khero to the locals and the present day Nikachu was known as Rinchenchu. Chore = Khero and Chizukang = Kyitsugang lie on the same mountain range separating the Nikachu and the Dangchu watersheds. Khero [Chore] is located within the aerial radius of around 5 kms from Kyitsugang [Chizukang].

With the help of David Long from the Royal Botanic Garden, Edinburgh and Pam Eveleigh from the Primula World, the type locality was traced and a team from the National Herbarium and Royal Botanical Garden, Serbithang under NBC made an expedition to the mountain east of Dangchu in June, 2021 (Fig. 1).

During the expedition, the team was faced by incessant rainfall and the footpath was barely noticeable since the cow herders of the Ramno grazing area stopped taking their cattle to the grazing area last year. The team took shelter in the wooden huts of the cow herders from Dangchu and ascended through steep cliffs towards Kyitsugang the next day. Despite incessant rainfall and cold mountain winds, the team finally found the lovely and tiny *Rhododendron pogonophyllum* flowering beautifully and precariously on the rocks and rocky soils on open hillsides at Kyitsugang at an altitude of 4,452 masl. Kyitsugang is considered by the residents of Dangchu to be the abode of their deity Kyitsub. *Rhododendron pogonophyllum* which was recorded in 1937 is thus rediscovered after 84 years in Bhutan.

The specimens collected is deposited in the National Herbarium of Bhutan (THIM) which is the official botanical repository and reference centre of the country. *Rhododendron pogonophyllum* Cowan & Davidian is a creeping subshrub which has similar flowers to that of *Rhododendron anthopogon* with small obovate leaves with rounded or retuse apex, rounded at base with scaly leaf on its underside.

Fig. 2-3. The rediscovered *Rhododendron pogonophyllum*

Orchid Micropropagation at the Royal Botanical Garden, Serbithang

Pem Zam, Sureeporn Nontachaiyapoom, Tshering Wangmo, Pema Yangdon, Kezang Tobgay, Nima Gyeltshen, Wangmo & Sampa

The natural habitats of wild orchids in Bhutan are currently threatened by numerous forest fires, road construction, rapid urbanization, construction of hydro power projects and climate change. Moreover, over-exploitation of economically valuable orchid species such as *Cymbidium hookerianum* and *Cymbidium erythraeum* is a major threat to biodiversity loss. To reduce the over-exploitation and collection of the orchid species from the wild, the Royal Botanical Garden has taken up micropropagation methods with technical support from the Thailand International Cooperation Agency (TICA).

Mass propagation of orchids is essential to species conservation and to ensure the sustainable uses of orchids in Bhutan which can be achieved through micropropagation. Micropropagation is a method of propagation in which extremely small plant tissues/seeds are taken from carefully selected mother plants and cultured under laboratory/in vitro conditions (Fig. 1-3).

Fig. 1. Tissue culture racks at the lab, NBC.

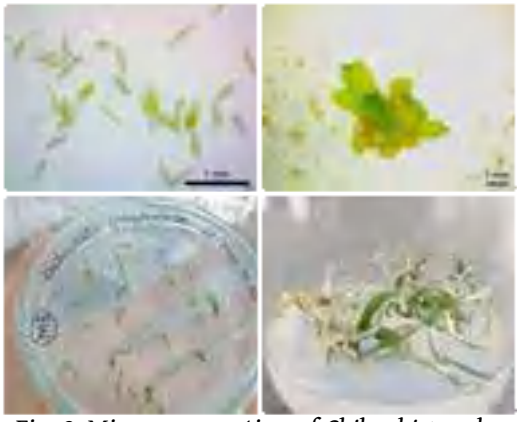


Fig. 2. Micropropagation of *Chiloschista gelephuense,* a new & endemic orchid species.

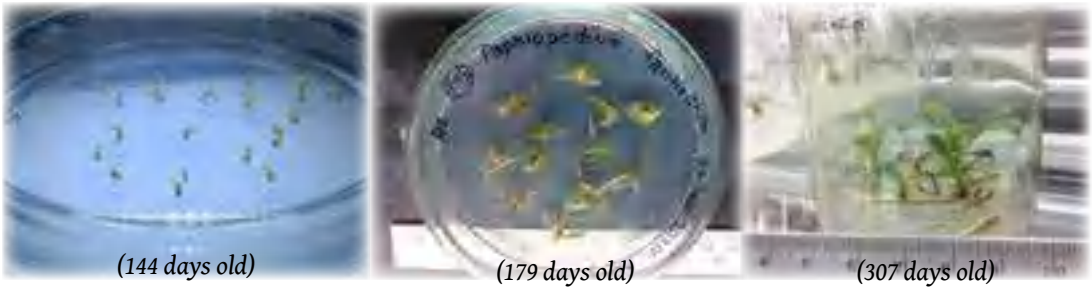


Fig. 3. Micro-propagation of *Paphiopedilum fairrieanum,* an endagered orchid species.

Micropropagation has the following advantages:

1. It is independent of seasonal changes and weather conditions.
2. It can rapidly produce large numbers of orchid seedlings compared to traditional means.
3. It may be possible to multiply plants that are very difficult to propagate bycuttings or any other methods.
4. Disease-free plant material is ensured. Seeds can be germinated with no risk of predation.
5. Under certain conditions, plant materials can be stored in vitro for considerable periods of time with little or no maintenance.
6. Tissue culture techniques are used for virus eradication, genetic manipulation, somatic hybridization and other procedures that benefit propagation, plant improvement, and basic research.

Hence, micro-propagation is a suitable method for mass propagation of Bhutanese orchids for both conservation and economic purposes. Micropropagation of economically valuable orchid species can discourage collection of orchids from the wild, supply orchid plants for household requirements and promote community income generation.

Fig. 4. Micropropagated orchid *(Chiloschista gelephuense)*

The Royal Botanical Garden with technical support from TICA received a tissue culture expert in 2020 for a period of one year. Ms. Sureeporn Nontachaiyapoom was attached with the Garden and over the course of her stay the garden has been successful in propagating 8 orchid species from seeds including critically endangered orchid species (Fig. 2 & 3). The orchid seed pods collected from different parts of the country and the orchidarium at the garden were cultured under laboratory conditions for a period of over a year and a half. The first ever successful mass propagation of orchid seeds resulted in over a thousand orchid seedlings which are now being taken out of the labs for ex-vitro acclimatization in the orchidarium (Fig. 4 & 5). The garden has also successfully initiated the establishment of an orchid micropropagation laboratory at the garden which is scheduled to be completed in the fiscal year 2021-2022 with the funding support from EU-RDCCRP (European Union- Rural Development and climate change response program).

Table 1. Orchid species propagated using the micropropagation method.

S. No.	Species	Number of seedlings obtained
1	*Paphiopedilum fairrieanum*	169
2	*Paphiopedilum venustum*	20
3	*Cymbidium eburneum*	95
4	*Cymbidium aliofolium*	174
5	*Neogyna gardneriana*	35
6	*Chiloschista gelephuense*	31
7	*Phalaenopsis lobbii*	15
8	*Coelogyne stricta*	10

The collaboration has also resulted in the development of protocols for orchid seed collection and storage and protocols for micropropagation of economically important, endangered and critically endangered orchids. The RBGS staff have also been trained on micropropagation techniques and management of the micropropagation laboratory. The garden aims to continue the mass propagation of orchids for ex-situ conservation, for exhibition and display on special occasions such as the national events of Bhutan, and for supplying orchid plants to communities under the income generation projects with the completion of the orchid micropropagation laboratory at the garden.

Fig. 5. Micropropagated orchids growing at the Orchid House.

The Biodiversity Interpretation Centre: First of its kind in the Country

Kezang Tobgay, Pem Zam, Nima Gyeltshen, Pema Yangdon, Tshering Wangmo, Wangmo & Sampa

The Biodiversity Interpretation Centre was inaugurated by His Excellency Lyonpo Yeshey Penjor, Minister of Agriculture and Forests on 22nd May, 2021 coinciding with the International Biodiversity Day and the Centre is dedicated to His Royal Highness Gyalsey Jigme Namgyel Wangchuck in commemoration of Gyalsey's fifth birthday.

Despite great success in achieving most of the objectives of the Royal Botanical Garden, one of the key areas with potential for further improvements was felt on education and interpretation programs, where activities to increase awareness on the importance of biodiversity and need for its conservation could be a flagship initiative. Realizing this limitation as well as the potential, the garden built an infrastructure with funding support from the EU sector support program to function as an interpretation centre. The momentum was followed by the development of additional inputs such as education and interpretation/outreach materials, displays, and educational programmes for various target groups funded by the Botanical Gardens Conservation International (BGCI), of which the Royal Botanical Garden, Serbithang has been a member since 2000. The final design, supply and installation of Biodiversity Interpretation materials were implemented in the year 2019 with funding support from European Union Rural Development Climate Change Response Programme, Royal Botanic Garden, Kew and technical support from the United Nations Development Program (UNDP).

The Biodiversity Interpretation Centre, established at the Royal Botanical Garden, Serbithang under the national Biodiversity Centre is the first of its kind in Bhutan. It is a one-stop hub that provides an overview of Bhutan's biodiversity and the term "interpretation" broadly refers to

Fig. 1. Inauguration of the Biodiversity Interpretation Centre (BIC) by His Excellency Lyonpo Yeshey Penjor, Minister of Agriculture & Forests on 22nd May 2021.

educational activities used in places like zoos, museums, heritage sites and national parks, to tell visitors about the significance or meaning of what they are experiencing. The Biodiversity Interpretation Centre will support the achievement of National Biodiversity Target One of "Increasing awareness on values of biodiversity" as it is the only facility within the vicinity of urban Thimphu. It will also aid in the financial sustainability initiatives of the botanical garden and thus is seen as an innovative financing mechanism since an increased number of visitors to the interpretation centre would lead to increased revenue collection through the sale of entry tickets.

Main objectives of the Biodiversity Interpretation Centre are to:

- Raise awareness on the richness of biodiversity and to encourage the people of Bhutan to value biodiversity.
- Make the public in Bhutan aware of their role in the conservation of biodiversity and inspire a love of nature.
- Increase the number of school visits to the garden and widen audience demographics.

The Interpretation Center is an integral part of the Royal Botanical Garden, which aims to provide an overall view and knowledge on Bhutan's biodiversity and to create awareness on the importance of biodiversity conservation. The Interpretation Centre comprises biodiversity information from all across Bhutan categorized into different display corners of plant and invertebrate specimens, wood samples, biodiversity research equipment, ethno-botanical artefacts, images, audio visual facilities and information display materials, among others.

The improved interpretation facilities and education programmes would lead to increased visits from the schools, which in turn will lead to increased awareness and care for biodiversity, nurturing the youth into environmentally conscious citizens. This has an indirect positive impact to the botanical garden and biodiversity conservation initiatives since in the long run, these motivated youths could become supporters of botanical gardens in particular and biodiversity conservation in general. The Biodiversity Interpretation Centre is accessible to the public for visits from Monday to Saturday, 9am to 5pm. The centre will remain closed on Sundays and government holidays.

Fig. 2. The Biodiversity Interpretation Centre at the Royal Botanical Garden Serbithang, Thimphu.

Native Plant Propagation at the Royal Botanical Garden Serbithang

Nima Gyeltshen, Pem Zam, Kezang Tobgay, Tshering Wangmo, Wangmo, Pema Yangdon & Sampa

One of the functions of the Royal Botanical Garden is to promote propagation of prioritized native plant species to reduce pressure on collection from the wild and to ensure their sustainable use. Plant propagation is the process of producing new plants. To achieve the above function, the native plant propagation facility (polycarbonate house) was constructed and completed with funding support from EU-RDCCRP. The Royal Botanical Garden produces several native plant species every year for beautification, landscaping and exhibition purposes.

The propagation facility will be used to initiate research trials on propagation and mass multiplication of native plants with potential for commercialization and restoration of threatened plants to the natural ecosystem. Saplings of native plants with commercial potential will be supplied to local communities to provide them an additional/alternative source of income and to build their resilience to the impacts of climate change on traditional farming systems and livelihood. Restoration of threatened plants to the natural ecosystem would support in restoring the diversity and resilience of the natural ecosystem. The facility with temperature control will also enable the garden to produce plants even in cold winters which has not been possible until now due to damage by frosts.

Fig.1. *Buddleja asiatica* growing at the Royal Botanical Garden Serbithang

Some of the commonly used methods for native plant propagation done at the Royal Botanical Garden are through:

1. Seedling

The native plants can be grown from the seeds. The plant species propagated through seedling at Garden are *Buddleja colvilei, Philadelphus tomentosa, Hydrangea heteromalla, Hydrangra aspera, Rosa macrophylla, Ligustrum compactum, Ligustrum confusum, Leycesteria formosa, Lonicera angustifolia, Maddenia himalaica, Osmanthus suavis, Prunus cerasoides, Prunus cornuta, Prunus napaulensis, Quercus glauca, Quercus griffithii, Ribes himalense, Schisandra grandiflora, Spiraea arcuata, Spiraea micrantha, Spiraea bella, Acer cappadocicum, Acer campbellii. Berberis asiatica, Berberis aristata, Clematis connata, Clematis montana, Daphne bholua, Euonymus grandiflorus, Euonymus lucidus, Ilex dipyrena, Ilex fragilis, Jasminum humile, Cotoneaster microphyllus, Cotoneaster bacillaris, Cornus capitata* and *Cupressus corneyana.*

2. Cuttings

Propagation from cuttings involves removing certain parts of a living plant and putting them in a growing medium so they form roots. Cuttings are a good way to obtain new plants, and often produce usable plants more quickly than seeds. The plant species propagated through cutting at the garden are *Buddleja colvilei, Philadelphus tomentosa, Hydrangea heteromalla, Hydrangra aspera, Rosa macrophylla, Spiraea arcuata, Spiraea micrantha, Spiraea bella, Clematis connata, Clematis montana, Hoya sp.* and *Jasminum dispermum.*

3. Air Layering

Air layering is a technique of producing new plants from a branch which is potted or wrapped in a moist growing medium while it is still attached to the parent plant. Air layering is done mainly in woody plants in the summer seasons. It is a great alternative for plants which are hard to propagate from cuttings. The plant species propagated through air layering at the garden are *Hydrangea heteromolla, Hydrangra aspera, Magnolia globosa* and *Rhododendron spp.*

Fig. 2. Native plant propagation house at the Royal Botanical Garden Serbithang

Journey of the Invertebrate Inventory in Bhutan

Choki Gyeltshen & Karma Dema Dorji

Invertebrates are a vital component of the ecosystem. Relatively little is known about the largest biodiversity component, the invertebrates. On the other hand, it has been increasingly and strongly realized that lack of up-to-date knowledge of the invertebrate fauna hampers dealing with serious environmental and climate change issues. A recent example is the introduction and rapid spread of the Giant African Snail, which was noticed only very late. Basic knowledge on the distribution and ecology of invertebrates is therefore of considerable importance both for nature conservation and for sustainable agriculture.

The Bhutan Trust Fund for Environmental Conservation (BTFEC) has acknowledged this and has from 2015 to 2017 enabled several Bhutanese institutes under the leadership of the National Biodiversity Centre (NBC), Ministry of Agriculture and Forests to initiate a baseline inventory of prioritized invertebrates in Bhutan. This project resulted in a network of Bhutanese institutes and experts cooperating on the study of invertebrates and the establishment of a National Invertebrate Repository at the National Biodiversity Centre, Thimphu. The collaborating institutions include Ugyen Wangchuck Institute for Conservation and Environmental Research (UWICER), College of Natural Resources (CNR), Sherubtse College, National Plant Protection Centre (NPPC), Royal Society for Protection of Nature (RSPN), and the Naturalis Biodiversity Center (Naturalis) in the Netherlands. The project focused on Bees and Wasps, Dragonflies and Damselflies, Snails and Slugs, Moths, and Lady Beetles.

Fig. 1. Collection of snail specimens from Samdrup Jongkhar.

Fig. 2. *Epiophlebia laidlawii*

Fig. 3. *Apis florea*

Fig. 4. *Rahula trongsaensis*

Fig. 5. *Oenopia mimica*

The collection of molluscs, moths, bees and wasps, and dragonflies and damselflies are still on-going and the specimen are deposited at the National Invertebrate Repository. With the advancement in the field of invertebrates, collection of DNA samples is also initiated, where the sequencings are carried out with the help of foreign institutions. Currently there are more than 20,000 specimens of invertebrates at the repository. Following guide books were published as a result of collaboration:

1. A field guide to the common dragonflies and damselflies of Bhutan.
2. A field guide to the common bees and wasps of Bhutan.
3. A field guide to the common moths of Bhutan.
4. A field guide to the common molluscs of Bhutan.
5. A field guide to the common lady beetles of Bhutan.

This project has also led to the publication of more than thirty (30) journal articles and discoveries of numerous species that are new to science and new to Bhutan. Few new species are still being discovered annually such as, *Pseudonapaeus accibhutanus, Sinoennea nimai, Sinoennea bhucylindrica*, etc discovered in 2021. Till date a total of 32 new species were discovered in the country through these collaborative efforts.

Table 1. List of 32 species new to science discovered through the Invertebrate Inventory.

S. No.	Species	Author (s)	Year
Dragonflies & Damselfies (Odonata)			
1	*Megalestes gyalsey*	Thinley Gyeltshen, Vincent J. Kalkman & Albert G. Orr	2017
Snails (Mollusca)			
2	*Rahula kleini*	Edmund Gittenberger, Pema Leda & Sherub Sherub	2017
3	*Rahula trongsaensis*	Edmund Gittenberger, Pema Leda & Sherub Sherub	2017
4	*Erhaia wangchuki*	Edmund Gittenberger, Pema Leda & Bjorn Stelbrink	2017
5	*Endothyrella bhutanensis*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Barna Pall-Gergely	2018
6	*Endothyrella spirostriata*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Barna Pall-Gergely	2018
7	*Endothyrella pemagatshel*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Barna Pall-Gergely	2018
8	*Truncatellina bhutanensis*	Edmund Gittenberger, Pema Leda & Sherub Sherub	2013
9	*Pseudopomatias barnai*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen	2019
10	*Cylindrophaedusa (Montiphaedusa) parvula*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen	2019
11	*Cylindrophaedusa (Montiphaedusa) tenzini*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen	2019
12	*Phaedusa adrianae*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen	2019
13	*Phaedusa chimiae*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen	2019
14	*Phaedusa sangayae*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen	2019
15	*Erhaia jannei*	Edmund Gittenberger, Pema Leda, Jigme Wangchuk, Choki Gyeltshen & Bjorn Stelbrink	2020
16	*Erhaia pelkiae*	Edmund Gittenberger, Pema Leda, Jigme Wangchuk, Choki Gyeltshen & Bjorn Stelbrink	2020
17	*Sinoennea bhucylindrica*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen	2021
18	*Sinoennea nimai*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen	2021
19	*Rahula namgayae*	Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen	2021
20	*Pupisoma (P.) paroense*	Edmund Gittenberger, Choki Gyeltshen, Pema Leda & Sherub Sherub	2021
21	*Pseudonapaeus accibhutanus*	Edmund Gittenberger, Choki Gyeltshen, Pema Leda & Sherub Sherub	2021
22	*Laevozebrinus parvus*	Edmund Gittenberger, Choki Gyeltshen, Pema Leda & Sherub Sherub	2021

S. No.	Species	Author (s)	Year
23	*Sculpteuconulus obliquistriatus*	Edmund Gittenberger, Choki Gyeltshen & Sherub Sherub	2021
24	*Philalanka bhutana*	Edmund Gittenberger, Choki Gyeltshen & Sherub Sherub	2021
Moths (Lepidoptera)			
25	*Eupoecilia jakarana*	Frans Groenen & Karma Wangdi	2019
26	*Eupoecilia gedui*	Frans Groenen & Karma Wangdi	2019
27	*Lumaria phuntschona*	Frans Groenen & Karma Wangdi	2019
28	*Borneogena trashiyana*	Frans Groenen & Karma Wangdi	2019
29	*Bactra cophinana*	Frans Groenen & Karma Wangdi	2019
30	*Penthostola subnigrantis*	Frans Groenen & Karma Wangdi	2019
31	*Metendothenia brunnofasciana*	Frans Groenen & Karma Wangdi	2019
30	*Peridaedala nigrifasciana*	Frans Groenen & Karma Wangdi	2019
31	*Epiblema albulusana*	Frans Groenen & Karma Wangdi	2019
32	*Pterophorus karmawangdi*	Cees Gielis & Karma Wangdi	2018

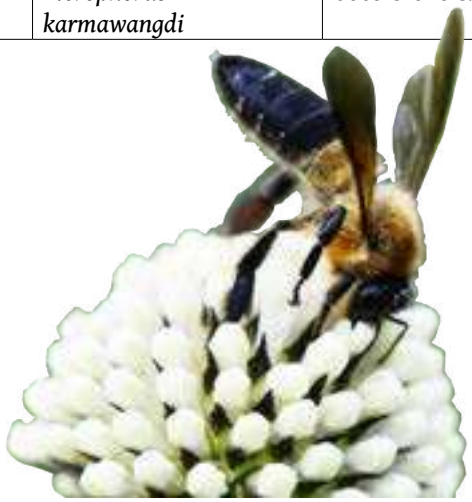


Fig. 6. Apis laboriosa

Fig. 7. *Eudocima salaminia*

Fig. 8. Archaeoattachus edwardsii

Fig. 9. Thiara scabra

Epididymal Semen Collection & Porcine Semen Cryopreservation Trial from Indigenous Pig

Tshewang[1], Sangay Dorji[2], Deki Gazom[1] & Tshering Dorji[1]

[1] Animal Genetic Resources Program, National Biodiversity Center, Thimphu, Bhutan.
[2] Livestock Production Officer, Dzongkhag Livestock Sector, Zhemgang, Bhutan.

Abstract

The epididymal semen collection and porcine semen cryopreservation trial from indigenous pigs was conducted in collaboration with Dzongkhag Livestock sector, Zhemgang from 2nd June to 11th June 2021. The trail once completed and protocols fully tested in field conditions, would be an important method of semen collection to collect semen from important livestock species from whom the conventional method of collection does not work. In total 100 doses of semen were collected from native pig and cryopreserved in the gene bank.

Introduction

The indigenous pigs in our country possess some of the valuable traits such as adaptability to poor quality feed, general robustness, less susceptibility to diseases and ability to thrive in a wide range of climatic conditions. Since, indigenous pig farming requires minimal inputs in terms of labour and feed quality; they are preferred by the low-income farmers over exotic pig breeds. The indigenous pigs are commonly reared under smallholder farming systems in our country. However, the population size of these indigenous pigs is decreasing at an alarming rate over the years and requires urgent attention for their conservation and sustainable utilization. The other key factors contributing to their decline is the religious stigma on slaughter, easily available imported pork in the market and introduction of high yielding exotic pig breeds in the country. Conservation of our local pig breeds particularly Sapha has become a necessity due to the fact that indigenous breeds have important gene / traits against emerging diseases as result of climate change. They are also crucial to maintain biodiversity and as baseline population for breeding disease resistant breeds for different environmental conditions. Further considering the growing economy and disposal income, there will be demand for high quality product and potential for high end niche product development and market. Given the unique features and role they play in our rural economy and household food security, it is very important to conserve these breeds for our future generations to come.

The Animal Genetic Resources Program has been rearing indigenous pigs (boar) for semen collection and semen cryopreservation on station. These animals are trained routinely with proper care and handling to mount dummy for semen collection. However, despite all efforts and time with all possible techniques

in training the indigenous boars; the program was not able to collect semen from the indigenous boars maintained on station. The main challenges in collecting semen from these animals using conventional and noninvasive method are that indigenous pigs are very difficult to train due to their semi-wild nature and very aggressive comparing to exotic pig breeds. Therefore, it is deemed necessary to collect semen using epididymal method (surgery) to conserve the germplasm of these important pig breeds for the future.

Objectives

- Diversify and strengthen semen collection methods in indigenous pig breeds.

Expected output

- Increased accessions in gene bank.
- Reviving of threaten livestock species.
- Maintain adequate number of semen doses from indigenous pig breeds.

Fig.1. Jitu phaab and Sapha, indigenous breed of pigs.

Materials & Methodologies

1. The epididymis is the coiled structure within the scrotum which stores spermatozoa (while they mature) until ejaculation.
2. Three boars at three months age were castrated. Both testes and associated structures including epididymis were removed using standard surgical castration procedures.
3. After removal, the excised testes are placed in sterile reseal able zip lock plastic bag and placed in an empty Styrofoam cooler to maintain temperature and transported to DVH lab for processing.
4. The temperature of the specimen is maintained during transport at around 37oC by placing ice packs in the bottom of the cooler. There are two basic methods for extracting semen from the epididymis; retrograde flushing of the semen through the epididymis and float-up method. The retrograde flushing method, which is the most common method, was used to harvest semen. The semen was harvested by slicing with sharp sterile scalpel the caudal portion of excised epididymis placed in a sterile Petri dish containing semen medium.
5. All the available Semen was harvested from both the epididymis. Semen diluent was immediately added to the harvested semen after measuring the concentration. Once suspended in the freezing extender, the cryopreservation process was carried out similar to semen collected by ejaculation method as per standard protocol

Fig. 2. Removal of testes and associated epididymis using standard surgical castration procedures and extraction of semen.

Results and Conclusion

In total 100 doses of semen were collected from the epidymis of three native pigs and conserved in the gene bank. The volume of semen collected was about 4-5 ml per animal. The concentration of spermatozoa was 290 - 345 x 10^6 per ml and average progressive motility was 80%. The Post thaw motility (PTM) after semen processing was 40%. After evaluating the semen quality parameters and PTM (after semen processing), the present method can be used to collect and cryopreserve genetic materials from important livestock species especially indigenous breeds, from which semen collection by non-surgical method is very difficult or impossible.

Table 1. Different parameters for semen quality.

Animal id	Vol. (ml)	Colour	Mass Activity	Initial Motility (%)	Conc. (*10^6)	Diluents added (ml)	Total doses processed	Total doses stored	PTM (%)
Pig 1	5	Milky	3	80	345	50	39	38	40
Pig 2	6	Milky	3	80	290	50	37	36	40
Pig 3	4	Milky	3	80	330	45	26	25	40
						Total	102	99	

11. Abstracts of Published Journal Articles July 2020 – June 2021

Orchids of Bhutan: The genus Spathoglottis

Stig Dalstrom, Choki Gyeltshen, Nima Gyeltshen, Kezang Tobgay, Ngawang Gyeltshen & Bhakta Bdr. Ghalley

The genus *Spathoglottis* Blume was described by Karl Ludwig von Blume in 1825 in Bijdragen tot de Flora van Nederlandsch Indië. The genus currently consists of approximately 50 species with some additional varieties and natural hybrids, distributed in India, Nepal, Bhutan, throughout subtropical Southeast Asia, China, Indonesia, New Guinea, Australia and the Pacific Islands. Until recently, only *Spathoglottis ixioides* (D.Don) Lindl., a rather small and yellow flowered species was known from Bhutan.

Published in Orchids, 530-533, American Orchid Society, July 2020

Amblyanthopsis bhotanica rediscovered in Bhutan after 181 years

Phuentsho & David G. Long

Amblyanthopsis bhotanica (C. B. Clarke) Mez (Primulaceae, though formerly placed in Myrsinaceae) is one of four species in this genus of Asiatic evergreen shrubs, which are found in India, Bhutan and the Philippines. In the Flora of Bhutan (Long & Rae 1999) it was treated in the closely-related genus *Ardisia* along with six other species. Both genera are distinctive in their somewhat leathery gland-dotted leaves, and when in ripe fruit by their bright red fleshy drupes. *Amblyanthopsis bhotanica* is rediscovered in 2019 from Jigmecholing gewog in Sarpang.

Published in Newsletter of Himalayan Botany No. 52: 4- 7. Aug. 2020.

Two new spotted *Chiloschista* species (Orchidaceae: Aeridinae) from Bhutan

Nima Gyeltshen, Choki Gyeltshen, Kezang Tobgay, Stig Dalstrom, Dhan Bdr. Gurung, Ngawang Gyeltshen & Bhakta Bdr. Ghalley

Two new spotted species of *Chiloschista* from Bhutan are described, illustrated, and compared with similar species. The second of the new species has been misidentified in previous publications as *C. lunifera* and *C. parishii*, and a comparison between the three is provided. It is also compared with *C. glandulosa*, which is a distinctly smaller-flowered species from the coastal area of southwestern India, and with *C. javanica* from Indonesia. The latter species and *C. parishii* are easily distinguished from both new species by having hairs on the backside and along the margins of the sepals and petals, as opposed to having virtually glabrous to indistinctly micro-pubescent sepals and petals for the new species. Although many spotted *Chiloschista* species are superficially similar, the differences can be better observed when studying the internal morphology of particularly the glandular callosity in the saccate lip. The morphological differences are often minute and difficult to describe in words, but are more easily recognized when compared with illustrations and photographs.

Published in Lankesteriana 20(3): 281-299, Oct. 2020, doi: http://dx.doi.org/10.15517/lank.v20i3.44149

The genera *Erhaia* and *Tricula* (Gastropoda, Rissooidea, Amnicolidae and Pomatiopsidae) in Bhutan and elsewhere in the eastern Himalaya

Edmund Gittenberger, Pema Leda, Jigme Wangchuk, Choki Gyeltshen & Bjorn Stelbrink

Shells of the Rissooidea species that are known from Bhutan are characterized. Tricula montana is reported from that country for the first time. Two *Erhaia* species from Bhutan are described as new to science, viz. *E. jannei* sp. nov., and *E. pelkiae* sp. nov., The holotypes of the *Erhaia* species that were described from Nepal are figured with photographs for the first time and compared with the congeneric taxa from Bhutan and India. *Erhaia nainitalensis* is considered a senior synonym of *E. chandeshwariensis*. An identification key is presented for the *Erhaia* species of the Himalayan foothills.

Published in ZooKeys 929; 1-17; 2020. https://doi.org/10.3897/zookeys.929.49987

Utricularia furcellata (Lentibulariaceae): A new record to Bhutan

Phub Gyeltshen & Sangay Dema

Five *Utricularia* species are described in the Flora of Bhutan. During a recent floristic exploration, specimens of *Utricularia* L. were collected from the Cool Broadleaved forests of Dzongkhalum, Trongsa district at an elevation of 2600 m. The specimens identified as *Utricularia furcellata* Oliv. is a new record to Bhutan, which is described and illustrated in this paper. *U. furcellata* is similar to *U. striatula* Sm., but can be distinguished easily by the shape of the lower corolla.

Published in BJNRD 7(1): 51-54, Nov. 2020

Flavonol Glycosides from the whitish flowers of *Primula alpicola* and *P. sikkimensis* var. *hopeana* in Bhutan

Takayuki Mizuno, Rinchen Yangzom, Hari Prasad Devkota, Yoshinori Murai, Rinchen Dorji, Kencho Dorji, Choki Wangmo, Choki Gyeltshen & Tsukasa Iwashina

Five flavonols were isolated from the whitish flowers of *Primula alpicola* and *P. sikkimensis* var. hopeana which belongs to the section Sikkimensis in Bhutan. Flavonoid composition of two *Primula* species were qualitatively the same and they were identified as quercetin 3-O-xylosyl-(1→2)-(rhamnosyl-(1→6)-glucoside) (1), quercetin 3-O-rutinoside (5). Compound 1 which might characterize in these species was reported from the family Primulaceae for the first time. Although gossypetin has been reported as principal yellow pigment in *Primula* species, it was not found in the whitish flowers of two *Primula* taxa.

Published in Bull. Natl. Mus. Nat. Sci., Ser. B, 46(4), pp. 185-194, Nov. 2020

Rhaphiolepis bengalensis (Roxb.) B.B.Liu & J.Wen: A New Record of Plant to Bhutan

Dhan Bdr. Gurung, Pema Tobgay, Tshering Dendup, Summit Subba, Wangchuk Blon, Phuentsho, Rinchen Dorji & Kencho Dorji

During a recent field trip in Wangdue Dzongkhag, few medium sized flowering trees were observed by roadside along Dangchhu river valley near Chuzomsa, and additionally from Phochhu in Punakha. The species was identified as *Rhaphiolepis bengalensis* (Roxb.) B.B.Liu & J.Wen, which is a new record of a plant to Bhutan. Formerly, the species was known as *Eriobotrya bengalensis* (Roxb.) Hook. f., which is now a synonym of *R. bengalensis*.

Published in Bhutan Journal of Natural Resources & Development 7(2): 91-93, Dec. 2020
DOI: https://doi.org/10.17102/cnr.2020.57

Flavonoids From the Flowers and Leaves of the Himalayan *Megacodon stylophorus* (Gentianaceae)

Tsukasa Iwashina, Rinchen Yangzom, Hari Prasad Devkota & Takayuki Mizuno

Five flavonol O-glycosides and 4 C-glycosylflavones were isolated from the flowers of the Himalayan *Megacodon stylophorus* (Gentianaceae). They were characterized as quercetin 3- O-glucoside (1), quercetin 3- O-rutinoside (2), kaempferol 3- O-glucoside (3), isorhamnetin 3- O-glucoside (4) and kaempferol 3,7-di- O-glucoside (5) (flavonols), and isovitexin (6), isoorientin (7), isovitexin X□- O-arabinoside (8) and isovitexin 4□- O-glucoside (9) (C-glycosylflavones) by ultraviolet, liquid chromatography-mass spectrometry, acid hydrolysis, nuclear magnetic resonance, and/or high-performance liquid chromatography and thin-layer chromatography comparisons with authentic samples. On the other hand, 5 C-glycosylflavones were isolated from the leaves and identified as 6, 7, 9, vitexin (10), and orientin (11). Although many C-glycosylflavones and xanthones have been reported from Gentianaceae species, flavonols are a minor occurrence in the family. Flavonoids were reported from the *Megacodon* species for the first time.

Published in Natural Product Communications 16(2): 1-4; Feb. 2021

Rahula revisited (Pulmonata: Euconulidae), with data for Bhutan, India (Assam), Laos, Vietnam and Indonesia, including two new species

Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen

New data for *Rahula* species in Bhutan are given, including a new species and an extended description of *R. trongsaensis* based on a newly found fully grown shell. The genus is known from only the eastern half of the country. Two hitherto overlooked nominal taxa of *Kaliella* from Assam are regarded as *Rahula* species resembling *R. trongsaensis*; photographs of syntypes of these taxa are presented. Additions to the species list for *Rahula* that was published earlier are added, including a new species for Indonesia, Sulawesi. An updated distribution map for the genus is provided.

Published in Journal of Conchology 44(1): 11-19 April 2021

Two high-altitude species of molluscs, new for Bhutan (Bivalvia, Sphaeriidae – Gastropoda, Lymnaeidae)

Edmund Gittenberger, Kezang Tobgay, Choki Gyeltshen & Hasko Nesemann

Pisidium stewarti and *Tibetoradix cf. hookeri,* two species that are known to occur at conditions that nowadays prevail at high altitudes, are reported from Bhutan for the first time. The records mark the southeastern border of the known recent occurrences for both species.

Published in Basteria 85(1); 13-17, May 2021.

The families Streptaxidae and Diapheridae (Gastropoda, Pulmonata) in Bhutan, with notes on some species occurring in Nepal and North-east India

Edmund Gittenberger, Pema Leda, Sherub Sherub & Choki Gyeltshen

The sister-families Streptaxidae and Diapheridae are reported from eastern Bhutan, with two and four species, respectively. The occurrence of the streptaxid *Perrottetia theobaldi* marks the northwestern limit of the genus *Perrottetia*. *Gulella (Huttonella) bicolor* is a widespread invasive species that might have its native range in Asia. Two of the four *Sinoennea* species that are reported from Bhutan, viz. *Sinoennea bhucylindrica* Gittenberger & Leda and *Sinoennea nimai* Gittenberger & Gyeltshen, are regarded as new to science. *Perrottetia theobaldi, Sinoennea vara* and maybe *S. latens* support the biogeographical link across the Brahmaputra between eastern Bhutan and the Khasi Hills in the Meghalaya state of India. Notes on three *Sinoennea* species occurring in the eastern Himalayan foothills, but not known from Bhutan, are added.

Published in Basteria 85(1); 73-81, May 2021

Orchids of Bhutan: *Phalaenopsis* Blume

Stig Dalstrom, Choki Gyeltshen, Nima Gyeltshen, Kezang Tobgay, Pem Zam, Tandin Wangchuk & Kezang Rinzin

The genus *Phalaenopsis* Blume was established by Karl Ludwig von Blume in his Bijdragen tot de Flora van Nederlansch Indië (Blume 1825). The genus was based on *Epidendrum amabile* Sw., which became *Phalaenopsis amabilis* (Sw.) Blume and is certainly one of the most appreciated, commercialized and hybridized species (480 F1 crosses) in this attractive genus. Today *Phalaenopsis* consists of about 75 accepted species, several natural hybrids and hundreds of synonyms. In other words, this is a very popular group of orchids among growers and botanists, amateurs and professionals alike. The genus is distributed from India to southern China, Thailand, Indochina, Malaysia and Indonesia to the Philippines and New Guinea (Pearce and Cribb 2002). Four species are currently documented from Bhutan, but this number will probably increase in the future as "orchid hunting" has become a "movement" in that country in recent years.

Published in Orchids, American Orchid Society, 362-367, May 2021

Flavonoids in the flowers of *Primula ×polyantha* Mill. and *Primula primulina* (Spreng.) H. Hara (Primulaceae)

Fumi Tatsuzawa, Takayuki Mizuno, Ryo Kikuchi, Kazuhisa Kato, Toru Ota, Yoshinori Murai, Rinchen Yangzom & Tsukasa Iwashina

Two undescribed anthocyanins and two undescribed flavonols were isolated from the flowers of *Primula ×polyantha* Mill., along with five known anthocyanins and four known flavonols. The two undescribed anthocyanins and the two undescribed flavonols were determined to be hirsutidin 3-O-β-galactopyranoside-5-O-β-glucopyranoside, 7-O-methyl-petunidin 3-O-β-galactopyranoside-5-O-β-glucopyranoside, quercetin 3-O-β-[(6””-acetylglucopyranosyl)-(1 → 2)-β-glucopyranosyl-(1 → 6)-β-glucopyranoside],andkaempferol3-O-β-[(6””-acetylglucopyranosyl)-(1→2)-β-glucopyranosyl-(1 → 6)-β-glucopyranoside] using chemical and spectroscopic methods. They were also found in the flowers of the Himalayan wild species, *Primula primulina* (Spreng.) H. Hara except for quercetin 3-O-β-[(6””-acetylglucopyranosyl)-(1 → 2)-β-glucopyranosyl-(1 → 6)-β-glucopyranoside]. The flower color variations of *P. ×polyantha* cultivars, reflected by the hue values (b*/a*) of the colors, were due to the glycosidic patterns in the anthocyanins and their concentrations in the petals. Moreover, in the *P. ×polyantha* cultivars with violet-blue flowers, both the intermolecular copigmentation occurs between hirsutidin 3-O-β-galactopyranoside-5-O-β-glucopyranoside and another flavonol, quercetin 3-O-β-glucopyranosyl-(1 → 2)-β-glucopyranosyl-(1 → 6)-β-glucopyranoside. Moreover, the flower color variation was affected by the pH value.

Published in Phytochemistry 189: 112827; June 2021. https://doi.org/10.1016/j.phytochem.2021.112827

Flavonoids from the leaves and flowers of the Himalayan *Cathcartia villosa* (Papaveraceae)

Tsukasa Iwashina, Rinchen Yangzom, Hari Prasad Devkota & Takayuki Mizuno

Five flavonols, four flavones and one C-glycosylflavone were isolated from the leaves of *Cathcartia villosa* which is growing in the Himalayan Mountains. They were characterized as quercetin 3-O-vicianoside (1), quercetin 7,4′-di-O-glucoside (3), quercetin 3-O-rutinoside (4), quercetin 3-O-glucoside (5), quercetin 3-O-arabinosylarabinosylglucoside (6) (flavonols), luteolin (7), luteolin 7-O-glucoside (8), apigenin (9), chrysoeriol (10) (flavones), and vicenin-2 (11) (C-glycosylflavone) by UV, LC-MS, acid hydrolysis, NMR and/or HPLC and TLC comparisons with authentic samples. On the other hand, two flavonols 1 and kaempferol 3-O-vicianoside (2) were isolated and identified from the flowers of the species. Flavonoids were reported from the genus *Cathcartia* in this survey for the first time. Their chemical characters were chemotaxonomically compared with those of related Papaveraceous genera, *Meconopsis* and *Papaver*.

Published in Biochemical Systematics and Ecology 96: 104267; June 2021. https://doi.org/10.1016/j.bse.2021.104267

The superfamilies Pupilloidea and Enoidea (Gastropoda, Eupulmonata) in Bhutan

Edmund Gittenberger, Choki Gyeltshen, Pema Leda & Sherub Sherub

The species of two gastropod superfamilies, i.e. Pupilloidea and Enoidea, that have been recorded in Bhutan, are described and illustrated. Five families with ten species in total are dealt with. Three species are described as new to science, viz. *Pupisoma (P.) paroense* Gittenberger et Leda, n. sp., *Pseudonapaeus occibhutanus* Gittenberger, Gyeltshen et Sherub, n. sp., and *Laevozebrinus parvus* Gittenberger, Gyeltshen et Leda, n. sp. Distribution maps are presented for all the species. Some biogeographical considerations are added.

Published in Folia Malacologica 29(2): 69-90, June 2021. DOI: https://doi.org/10.12657/folmal.029.009

Conspicuously sculptured small shells from Bhutan: *Philalanka bhutana* sp. nov. and *Sculpteuconulus obliquistriatus* gen. et sp. nov.

Edmund Gittenberger, Choki Gyeltshen & Sherub Sherub

Two new species and a new genus of terrestrial snail are diagnosed and described from Bhutan: *Philalanka bhutana* sp. nov. and *Sculpteuconulus obliquistriatus* gen. et sp. nov. The shells of both species are small (widths respectively ≤1.6 and 3.3 mm), broader than high, their spires somewhat depressed, and with the surface sculpturing conspicuous and distinctive. Our reliance on conchological characters means that there is some uncertainty about their broader systematic placements. Distribution maps are provided, showing that both species are widely distributed in Bhutan, and the shells are figured with photographs and scanning-electron-microscope images.

Published in Archiv für Molluskenkunde, June, 2021 DOI. https://doi.org/10.1127/arch.moll/150/005-011

List of Publications

PUBLICATIONS	YEAR
BOOKS/REPORTS	
A pictorial book of the ornamental plants and orchids of Royal Botanical Garden, Serbithang, Vol. I	2013
National Biodiversity Strategy and Action Plan (NBSAP)	2014
Access and Benefit Sharing Policy 2015	2015
The History of the introduction and adoption of important food crops in Bhutan (Rice, Maize, Potato and Chili)	2015
Plant Genetic Resources, Bhutanese Perspective	2000
Plant Genetic Resources of Bhutan Vol. I: Field Crops	2008
HARVESTS, Farmers Success Stories	2016
Endemic plants of Bhutan Himalaya	2015
A century of new orchid records of Bhutan	2016
National cereals Conservation strategic action plan	2016
Conservation, Development and Sustainable Use of Crop Genetic Resources for Livelihood and Food Security	2016
A field guide to the selected trees, shrubs and herbs of Tangsibji hydropower project area	2017
A pictorial guide to the trees and shrubs of Royal Botanical Garden, Serbithang. Vol. II	2017
A field guide to the common dragonflies and damselflies of Bhutan	2017
A field guide to the common bees and wasps of Bhutan	2017
A field guide to the common moths of Bhutan	2017
A field guide to the common molluscs of Bhutan	2017
A field guide to the common lady beetles of Bhutan	2017
Animal Genetic Resources of Bhutan	2008
Access and Benefit Sharing Toolkit for the Management of Genetic Resources and Associated Traditional Knowledge	2018
A Pictorial Guide to Major Invasive Plants of Bhutan	2018
A Pictorial Guide to Alpine Plants of Bhutan Himalaya	2018
Pteridophytes of Bhutan	2009
NBC Vision 2030	2018
Biodiversity Statistics of Bhutan 2017	2019
Bhutan Biodiversity Portal User Manual	2021
Biodiversity Conservation and Management Initiatives in Bhutan	2006
Characterization Catalogue and Pictorial Varietal Descriptions on Traditional Paddy Varieties *(Oryza sativa)* Conserved in the National Crop Genebank	2020
RESEARCH PAPERS/ARTICLES	
Morphological variations of native chicken types in backyard farms of Bhutan	2017
Genetic diversity of population structure of traditional horse breeds of Bhutan	2018
Community Perspectives on the On-Farm Diversity of Six Major Cereals and Climate Change in Bhutan	2015

PUBLICATIONS	YEAR
Immunological tolerance of Bhutanese native chicken to Infectious Bursal Disease Virus infection	2016
Mountain communities workshops on climate change and biocultural heritage	2014
Dancing butterflies of the East Himalayas: New *Meconopsis* species from East Bhutan, Arunachal Pradesh and South Tibet	2017
A new species of *Meconopsis*	2016
Roscoea megalantha (Zingiberaceae), A new species from eastern Bhutan and India	2017
Decline of Jakar sheep population in pastoral communities of Bhutan: A consequence of diminishing utility, alternate income opportunities and increasing challenges	2017
Assessment of genetic diversity of Mithun (Bos frontalis) population in Bhutan using microsatellite DNA markers	2017
Flower pigments Black Pea *Thermopsis barbata* (Fabaceae) in Bhutan	2017
Morphological diversity of principal horse populations of Bhutan	2017
Phenotypic and genetic parameters for milk yield in traditional Nublang cattle *(Bos indicus)* of Bhutan	2015
A new striking *Spathoglottis* (Orchidaceae: Collabiinae), Honoring Her Majesty The Queen of Bhutan.	2017
The genus *Vanda*	2015
An expected alleged natural *Vanda* hybrid	2017
The genus *Phaius*	2015
To be or not to be a *Chamaegastrodia*	2014
Erhaia Davis & Kuo (Gastropoda, Rissooidea, Amnicolidae) also in Bhutan	2017
Gastropods in Bhutan, the genus *Rahula* (Pulmonata: Helicarionidae).	2017
The first record of the cosmopolitan slug, *Deroceras laeve* (Gastropoda, Pulmonata, Agriolimacidae) in Bhutan	2018
Orchids of Bhutan: *Phalaenopsis* Blume	2021
Two high-altitude species of molluscs, new for Bhutan (Bivalvia, Sphaeriidae – Gastropoda, Lymnaeidae)	2021
The families Streptaxidae and Diapheridae (Gastropoda, Pulmonata) in Bhutan, with notes on some species occurring in Nepal and North-east India	2021
Rahula revisited (Pulmonata: Euconulidae), with data for Bhutan, India (Assam), Laos, Vietnam and Indonesia, including two new species	2021
Flavonol Glycosides from the Whitish Flowers of *Primula alpicola* and *P. sikkimensis* var. *hopeana* in Bhutan	2020
Orchids of Bhutan: The genus *Spathoglottis*	2020
Climate change effects on wildfire hazards in the wildland-urban-interface – Blue pine forests of Bhutan	2020
Bhutan Biodiversity Portal: Citizen Science initiative in Bhutan.	2019
Bhutan's Challenges in Biodiversity Informatics.	2019
Anthocyanins and flavonols from the blue flowers of six *Meconopsis* species in Bhutan.	2019
A new spotted *Chiloschista* (Orchidaceae: Aeridinae) from Bhutan.	2019
Orchids of Bhutan: the genus *Thunia*	2019
Orchids of Bhutan: the genus *Diplomeris.*	2019

PUBLICATIONS	YEAR
Distribution and habitats of *Paphiopedilum* Pfitzer known to occur in Bhutan.	2019
Pentasacme wallichii Wall. & Wight. (Family: Apocynaceae): A first record to Bhutan.	2019
New species discoveries and records in Bhutan Himalaya	2018
Distributional patterns of molluscan taxa in Bhutan.	2018
Flavonol glycosides in the flowers of the Himalayan *Meconopsis paniculata* and *Meconopsis integrifolia* as yellow pigments	2018
Development of a national repository for aquatic biodiversity in Bhutan.	2017
The superfamilies Pupilloidea and Enoidea (Gastropoda, Eupulmonata) in Bhutan.	2021
Bhutanese snails, the smallest one: *Truncatellina bhutanensis* spec. nov. (Gastropoda, Pulmonata, Vertiginidae).	2013
The genera *Erhaia* and *Tricula* (Gastropoda, Rissooidea, Amnicolidae and Pomatiopsidae) in Bhutan and elsewhere in the eastern Himalaya.	2020
Rhaphiolepis bengalensis (Roxb.) B.B.Liu & J.Wen: A New Record of Plant to Bhutan	2020
Two new spotted *Chiloschista* species (Orchidaceae: Aeridinae) from Bhutan.	2020
Utricularia furcellata (Lentibulariaceae): A new record to Bhutan.	2020
Flavonoids from the leaves and flowers of the Himalayan *Cathcartia villosa* (Papaveraceae)	2021
Flavonoids From the Flowers and Leaves of the Himalayan *Megacodon stylophorus* (Gentianaceae).	2021
Amblyanthopsis bhotanica rediscovered in Bhutan after 181 years.	2020
Flavonoids in the flowers of *Primula ×polyantha* Mill. and *Primula primulina* (Spreng.) H. Hara (Primulaceae).	2021
Anthocyanins from the Red Flowers of *Meconopsis wallichi* in Bhutan	2018
Elevational seed plants richness patterns in Bhutan, Eastern Himalaya	2017
Biodiversity inventories in high gear: DNA barcoding facilitates a rapid biotic survey of a temperate nature reserve	2015
Geographical Distribution New Herpetofaunal Records from the Kingdom of Bhutan Obtained through Citizen Science	2020
Number of species in Bhutan	2019
Himalayan Alpine Vegetation, Climate Change and Mitigation	2014
Orchid Explorers on the Trail of Gaurs and Elephants	2016
Thunder Dragon Orchids: A Conservation Project Takes Root in Bhutan	2012
National Action Plan Biodiversity Persistence and Climate Change	2011
Farm animal genetic resources in Bhutan	2013
The subfamily Phaedusinae in Bhutan (Gastropoda, Pulmonata, Clausiliidae)	2019
The family Pupinidae in Bhutan (Gastropoda: Caenogastropoda: Cyclophoroidea)	2019
Endothyrella Zilch, 1960 in Bhutan (Gastropoda: Pulmonata: Plectopylidae), with a description of three new species	2018
First record of *Carychium* in Bhutan (Gastropoda, Ellobiodea)	2017
Conspicuously sculptured small shells from Bhutan: *Philalanka bhutana* sp. nov. and *Sculpteuconulus obliquistriatus* gen. et sp. nov.	2021

PUBLICATIONS	YEAR
Coordinated by NBC (Invertebrate Project)	
New records of social wasps (Hymenoptera: Vespinae: Vespa and Provespa) from Bhutan	2017
The Honey Bees (Hymenoptera: Apidae) of Bhutan with a key to the Apis species	2016
New record of Carpenter bees (Hymenoptera: Apidae: Xylocopinae) from Bhutan	2016
Study of Paper wasps (Hymenoptera: Vespidae: Polistinae) of Bhutan	2016
Taxonomic study of social vespid wasps (Hymenoptera: Vespidae: Vespinae & Polistinae) in Bhutan	2017
New records of petiolate potter wasps (Hymenoptera: Vespidae: Eumeninae) from Bhutan	2016
New record of scoliid wasps (Hymenoptera: Scoliidae: Scoliinae) from Bhutan	2017
A survey of Odonata from eastern Bhutan, with nine new national records	2017
Odonata records from western Bhutan, with six new records and a note on the synonymy of *Himalagrion* with *Coenagrion*	2017
Bibliography and checklist of the dragonflies and damselflies of Bhutan	2017
Records of dragonflies from western Bhutan collected in October 2015.	2016
Honouring His Royal Highness the Crown Prince of Bhutan: *Megalestes gyalsey* (Odonata: Synlestidae).	2017
Taxonomic review of the superfamily Pyraloidea in Bhutan (Lepidoptera).	2016
A preliminary checklist of the Coccinellidae of Bhutan (Insecta: Coleoptera)	2019
A new species of *Eumerus* (Diptera, Syrphidae) from the Kingdom of Bhutan, the easternmost representative of the bactrianus subgroup	2020
Additional reports of solitary potter wasps (Hymenoptera: Vespidae: Eumeninae) in Bhutan	2018
First report of the ectoparasitoid wasp of genus *Leucospis* (Hymenoptera: Chalcidoidea: Leucospidae) from Bhutan	2017
New records of hover wasps (Hymenoptera: Vespidae: Stenogastrinae) from Bhutan	2017
Checklist of the dragonflies and damselflies (Insecta: Odonata) of Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka	2020

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ANNEXURES

Annexure 1.
List of the species of new collections to the National Herbarium during the fiscal year 2020-21:

S.No.	Species	Family	Remarks
1	*Balanophora dioica*	Balanophoraceae	
2	*Barbarea vulgaris*	Brassicaceae	
3	*Begonia annulata*	Begoniaceae	
4	*Begonia megaptera*		
5	*Begonia ovatifolia*		
6	*Bulbophyllum guttulatum*	Orchidaceae	
7	*Bulbophyllum hymenanthum*		
8	*Calanthe pachystylis*		
9	*Calanthe yuksomnensis*		
11	*Canarium strictum*	Burseraceae	New record
12	*Cestrum nocturnum*	Solanaceae	New record
13	*Chiloschista densiflora*	Orchidaceae	
14	*Clerodendrum colebrookeanum*	Lamiaceae	
15	*Clerodendrum viscosum*		
16	*Corallodiscus cooperi*	Gesneriaceae	
17	*Corydalis oligantha*	Papaveraceae	
18	*Cotoneaster rotoundifolius*	Rosaceae	
19	*Cryptocarya amygdalina*	Lauraceae	
20	*Cyclocodon parviflorus*	Campanulaceae	
21	*Decaisnea insignis*	Lardizabalaceae	
22	*Dendrobium denudans*	Orchidaceae	
23	*Dendrobium longicornu*		
24	*Duranta erecta*	Verbenaceae	
25	*Epigeneium rotundatum*	Orchidaceae	
26	*Eriobotrya benghalensis*	Rosaceae	New record
27	*Eriobotrya petiolata*		
28	*Eriocaulon viride*	Eriocaulaceae	
29	*Ficus benghalensis*	Moraceae	
30	*Ficus hispida*		
31	*Ficus racemosa*		
32	*Flemingia strobilifera*	Fabaceae	
33	*Flueggea virosa*	Phyllanthaceae	
34	*Gastrochilus calceolaris*	Orchidaceae	

S.No.	Species	Family	Remarks
35	*Gaultheria hookeri*	Ericaceae	
36	*Glochidion acuminatum*	Phyllanthaceae	
37	*Gmelina arborea*	Lamiaceae	
38	*Gordonia excelsa*	Theaceae	
39	*Gynura pseudochina*	Asteraceae	
40	*Habenaria arietina*	Orchidaceae	
41	*Hemidesmus indicus*	Apocynaceae	New record
42	*Horsfieldia kingii*	Myristicaceae	
43	*Hoya arnottiana*	Apocynaceae	
44	*Ipomoea campanulata*	Campanulaceae	New record
45	*Iris decora*	Iridaceae	
46	*Jasminum ritchiei*	Oleaceae	New record
47	*Liparis cordifolia*	Orchidaceae	
48	*Litsea laeta*	Lauraceae	
49	*Lobelia nubigena*	Campanulaceae	
50	*Ludwigia octovalvis*	Onagraceae	
51	*Mallotus tetracoccus*	Euphorbiaceae	
52	*Manihot esculenta*	Malvaceae	New record
53	*Meconopsis sherriffii*	Papaveraceae	
54	*Moneses uniflora*	Ericaceae	New record
55	*Mussaenda glabra*	Rubiaceae	
56	*Neogyna gardneriana*	Orchidaceae	
57	*Nicotiana tabacum*	Solanaceae	
58	*Notholirion campanulatum*	Liliaceae	
59	*Oberonia acaulis*	Orchidaceae	
60	*Onosma emodi var. stelligera*	Boraginaceae	
61	*Onosma paniculata*		
62	*Parasassafras confertiflora*	Lauraceae	
63	*Persea fructifera*		New record
64	*Phaius flavus*	Orchidaceae	
65	*Phaius mishmensis*		
66	*Poikilospermum naucleiflorum*	Urticaceae	
67	*Primula bhutanica*	Primulaceae	
68	*Primula dryadifolia*		
69	*Primula flagellaris*		
70	*Primula hopeana*		
71	*Primula reticulata*		
72	*Primula strumosa*		
73	*Primula tsariensis*		

S.No.	Species	Family	Remarks
74	*Prunus napaulensis*	Rosaceae	
75	*Pueraria edulis*	Fabaceae	
76	*Pyracantha crenulata*	Rosaceae	
77	*Rhododendron × decipiens*	Ericaceae	
78	*Rhododendron argipeplum*		
79	*Rhododendron dalhousiae var. rhabdotum*		
80	*Rhododendron kesangiae var. album*	Ericaceae	
81	*Rhododendron lindleyi*	Ericaceae	
82	*Rhododendron niveum*	Ericaceae	
83	*Rhododendron pendulum*		
84	*Rhododendron pogonophyllum*		
85	*Rhododendron x candelabrum*		
86	*Rhynchotechum ellipticum*	Gesneriaceae	
87	*Rhynchotechum vestitum*		
88	*Ribes orientale*	Grossulariaceae	
89	*Saxifraga flavida*	Saxifragaceae	Type population, rediscovery
90	*Saxifraga thiantha*		
91	*Schefflera tenuis*	Araliaceae	
92	*Schizopepon bicirrhosa*	Cucurbitaceae	
93	*Sida urens*	Malvaceae	New record
94	*Silene latifolia*	Caryophyllaceae	New record
95	*Sisyrinchium rosulatum*	Iridaceae	
96	*Spiranthes hongkongensis*	Orchidaceae	
97	*Styrax grandiflorus*	Styracaceae	
98	*Swertia pseudohookeri*	Gentianaceae	
99	*Swida oblonga*	Cornaceae	
100	*Tetrastigma planicaule*	Vitaceae	New record
101	*Thlaspi andersonii*	Brassicaceae	
102	*Tricyrtis maculata*	Liliaceae	
103	*Utricularia recta*	Lentibulariaceae	
104	*Zeuxine affinis*	Orchidaceae	

Annexure 2.
List of fern species added to the National Herbarium during the fiscal year 2020 - 2021:

S. No	Species	Family	Location
1	*Arachniodes henryi*	Dryopteridaceae	Trongsa
2	*Arachniodes sp*	Dryopteridaceae	Trongsa
3	*Asplenium ensiforme*	Aspleniaceae	Zhemgang
4	*Asplenium obscurum*	Aspleniaceae	Zhemgang
5	*Asplenium yoshinagae*	Aspleniaceae	Zhemgang
6	*Athyrium distans*	Athyriaceae	Zhemgang
7	*Cheilanthes albomarginata*	Pteridaceae	Zhemgang
8	*Coniogramme pubescens*	Pteridaceae	Zhemgang
9	*Cyrtomium fortunei*	Dryopteridaceae	Tongsa
10	*Cystopteris fragilis*	Cystopteridaceae	Zhemgang
11	*Diplazium stoliczkae*	Woodsiaceae	Tongsa
12	*Dryopteris wallichiana*	Dryopteridaceae	Wangduephodrang
13	*Equisetum diffusum*	Equisetaceae	Wangduephodrang
14	*Histiopteris incisa*	Dennataedtiaceae	Zhemgang
15	*Huperzia hamiltonii*	Lycopodiaceae	Zhemgang
16	*Hymenophyllum polyanthos*	Hymenophyllaceae	Zhemgang
17	*Lemmaphyllum rostratum*	Polypodiaceae	Zhemgang
18	*Lepisorus loriformis*	Polypodiaceae	Zhemgang
19	*Lepisorus microsphaerus*	Polypodiaceae	Zhemgang
20	*Lepisorus thunbergianus*	Polypodiaceae	Zhemgang
21	*Leptochilus decurrens*	Polypodiaceae	Zhemgang
22	*Lindsaea odorata*	Lindsaeaceae	Zhemgang
23	*Leptochilus pedunculatus*	Polypodiaceae	Wangduephodrang
24	*Loxogramme involuta*	Polypodiaceae	Wangduephodrang
25	*Notholaena himalaica*	Pteridaceae	Wangduephodrang
26	*Plagiogyria sp*	Plagiogyriaceae	Wangduephodrang
27	*Polystichum nepalense*	Dryopteridaceae	Wangduephodrang
28	*Polystichum stimulans*	Dryopteridaceae	Trashigang
29	*Pteris griffithii*	Pteridaceae	Mongar
30	*Pteris wallichiana*	Pteridaceae	Trashigang
31	*Pyrrosia stenophylla*	Polypodiaceae	Zhemgang
32	*Selaginella involvens*	Selaginellaceae	Tongsa
33	*Tectaria fuscipes*	Dryopteridaceae	Zhemgang
34	*Tectaria polymorpha*	Dryopteridaceae	Zhemgang
35	*Tomophyllum donianum*	Polypodiaceae	Wangduephodrang
36	*Trichomanes striatum*	Hymenophyllaceae	Zhemgang
37	*Vittaria doniana*	Pteridaceae	Trashigang
38	*Vittaria flexuosa*	Pteridaceae	Zhemgang

Annexure 3.
List of grass species added to the National Herbarium during the fiscal year 2020-21:

S. No.	Species Name	Collection location
1	*Saccharum spontaneum*	Missina, Punakha
2	*Schizachyrium delavayi*	Thimphu
3	*Pennisetum flaccidum*	Thimphu
4	*Cymbopogon bhutanicus*	Mongar
5	*Arundinella bengalensis*	Paro
6	*Bromus staintonii*	Lamai Gonpa
7	*Chloris virgata*	Rabuna, Wangdiphodrang
8	*Echinochloa crus-galli*	Nobding
9	*Isachne albens*	Trongsa
10	*Brachypodium sylvaticum*	Taba, Thimphu
11	*Danthonia cumminsii*	Chele La
12	*Paspalum dilatatum*	Thimphu
13	*Dactylis glomerata*	Thimphu
14	*Poa rajbhandarii*	Talakha, Thimphu
15	*Helictotrichon parviflorum*	Motithang, Thimphu
16	*Avena fatua*	Drukgyel, Paro
17	*Phalaris minor*	Drukgyel, Paro

Annexure 4.
Contributors to the Status Report:

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