



Wetland Medicinal Plants of Eastern Himalayan Highlands of Gasa District, Bhutan

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Authors' contribution

This work was carried out in collaboration between both authors. Author ST designed the study, wrote the protocol and wrote the first draft of the manuscript. Author PT performed the statistical analysis and literature searches. Both the authors read and approved the final manuscript.

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ABSTRACT

This paper documents the medicinal plant species in wetlands of the Eastern Himalayan Highlands of Gasa District, Bhutan. A random quadrat sampling method was used to assess the presence-absence of species. The study was conducted at Khatoed and Khamaed gewogs (blocks), Gasa District between January and December 2018. Identification of medicinal plant species and families were done in consultation with a botanist at the herbarium in Thimphu and volumes of Flora of Bhutan were referred. Based on the published and authentic scientific literature, information on medical uses of plant parts was collected. A total of 74 species of medicinal plant species in the wetlands, distributed in 69 genera and 43 families have been recorded. The study suggests preserving invaluable wetland medicinal plants and integrating ethno-medicinal practices in our lives.

Keywords: *Wetlands; medicinal plants; diseases; Bhutan; Himalaya.*

1. INTRODUCTION

Medicinal plants play a vital role in the lives of almost all people. About 65-80% of the world

population uses ethno-medicine for their primary health cares [1]. World Health Organization [2] reported an increase in use of herbal remedies as increased number of governments and health

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practitioners accepted and integrated ethno-botanical practices. In the world, plant-based companies like traditional medicine and aromatic cosmetic industries uses more than 13,000 plant species of which 8,000 species are used in South Asia alone [3,4]. From South Asian countries, India and China is reported to use 20% and 18.5% of their plants flora as medicinal plants respectively [5]. Muzzafar et al. [6] also confirmed that 85% of ethno-medicines used for primary health cares are from the plant derivatives.

Bhutan practiced traditional medicine similar to neighboring Tibet and Mongolia since 2500 years ago and known as the 'men-jong' the 'Land of Medicinal Plant' for possessing wealth of medicinal plant species [1,7]. This may be true because Bhutan has currently 70.46% of forest cover [8], which is greater than the constitutionally mandated 60% [9]. These abundant invaluable ethno-botanical and ethno-medicinal plants has provided main source of livelihood for rural and semi-urban people of Bhutan [8,10]. Bhutanese people in the past had used raw medicinal plants for ailment against many diseases due to high cost and inaccessible to conventional modern medicines. Plant species having medicinal, social and economical values were found mostly concentrated in wetland ecosystem [11,12]. In addition, wetland biodiversity is also known to provide mostly medicine, food and fodder [4] besides being critical habitat for animal and plant communities and serving as the bases of food chain [12,13].

In 1967, Bhutanese Government recognized traditional medicine as an alternative healthcare system by entrusting Pharmaceutical and Research Unit (PRU) under Institute of Traditional Medicine Service (ITMS) with manufacturing of traditional medicines in the country [7]. More than 5603 high altitude plant species are recorded in the pharmacopoeia of Bhutanese traditional medicine [5]. Currently, ITMS formulates 98 traditional herbal compounds using 267 species [7]. The medicinal plants in commercially viable amount were collected from Lingzhi in Thimphu and Langthel in Trongsa [14]. However, data on collection of these plants from lower montane areas including wetlands is scarce, despite wetland biodiversity known for medicinal, social and economic values [11,12]. Ever since the government officially recognized traditional medicines in the country, unsustainable harvesting like poaching and illegal trade of important medicinal plants has taken place,

threatening these plant species [8]. The other common threat includes deforestation, overgrazing, overexploitation, soil erosion, habitat fragmentation, and tourist upsurge [12,6,8,15]. The loss of these plants resources will not only extinct ethno-medical and ethno-botanical practices, but will also affect the health care system and the ecosystem of the nature.

In pursuit of protecting, promoting and promulgating Traditional Medicine and preserving rich wetland biodiversity, the current paper is undertaken with the following objectives: (a) to provide checklist of medicinal plants in wetlands, (b) categorize medicinal plant parts for different medical uses found in wetland vegetation in Bhutan.

2. MATERIALS AND METHODS

2.1 Study Area

Study was conducted in Khamaed and Khatoed gewogs of Gasa District. The study area is a part of Jigme Dorji National Park in Bhutan. The wetlands studied, mainly occurred in the slopes, bottomlands, edges of ericaceous shrub lands, in depressions, fallow lands, adjoining managed wetlands, along small streams, and forest fragments bordered by natural vegetation [13]. The elevation for the wetlands ranges from 1597 to 2538 m above sea level, that extends roughly 28 km between these two blocks. The area experiences the mean annual (2008-2017) rainfall and air temperature from 498-1824 mm and 5.16 – 15.63°C, respectively (National Center for Hydrology and Meteorology, 2018).

2.2 Data Collections and Plant Identifications

Prior to field survey, a research permit (Applicant ID: 18623722325AIECE2754986, dated 05/01/2018) was obtained from the Ugyen Wangchuk Institute for Conservation and Environment Research, MoAF, RGoB, Bhutan. Floristic inventory and collection of specimens were done from January to December 2018. A random quadrat sampling method was used to assess the presence-absence of species [16]. The plant species from each site were collected with nametag, date and brief description of their habitat. These collected plant specimens were taken to Herbarium, Thimphu, Bhutan for confirmation in consultation with experienced staff/Botanists. Flora of Bhutan [17,18,19,20, 21,22,23,24,25] was used for the identification of

species and families. All the voucher specimens were deposited at the Herbarium, National Biodiversity Center, Thimphu, Bhutan.

The information on medicinal uses of plant parts (roots, rhizomes, stems, flowers, bulbs, barks, fruits, leaves, whole parts) were collected from published and authentic scientific literatures; journals, practical guidebooks, and thesis books [26]. The category of disease groups [27] and life form groups [7] were followed with slight modifications.

3. RESULTS AND DISCUSSION

3.1 Medicinal Plants and their Life form

A total of 74 species of medicinal plants in the wetlands, distributed in 69 genera and 43 families have been recorded. The three most dominant families represented for medicinal plants were Rosaceae, Ericaceae and Asteraceae, and Orchidaceae, having 7, 6, and 4 species, respectively (Table 1). This indicates that these species representation are from the wetland habitat as they are acid loving plants

[16]. Similar study conducted in Eastern Bhutan also reported that the most represented medicinal plant families were Asteraceae and Rosaceae [8]. This presence of family dominance indicates that their collections of specimens may be from wetland areas. However, similar study conducted in Nepal and China recorded Asteraceae in the top three dominant families (Poaceae, Cyperaceae, Asteraceae) of wetland vegetation [11,4].

The herbaceous and shrub life form were the most abundant species represented with 58% and 30% while the trees and lianas were least represented at 7% and 5% of the total species (Fig. 2). An occurrence of higher proportion of shrubs and herbs is an indication of wetland vegetation [16]. Such distribution may be considered as the typical distribution in Himalayan temperate region [26] including lower montane areas [8]. This result is limited to present study and may not represent the actual status of life form of medicinal plants within wetlands in Bhutan. Every species recorded is provided with family name, life form, medicinal use and the part used (Table 1 and Fig. 3).

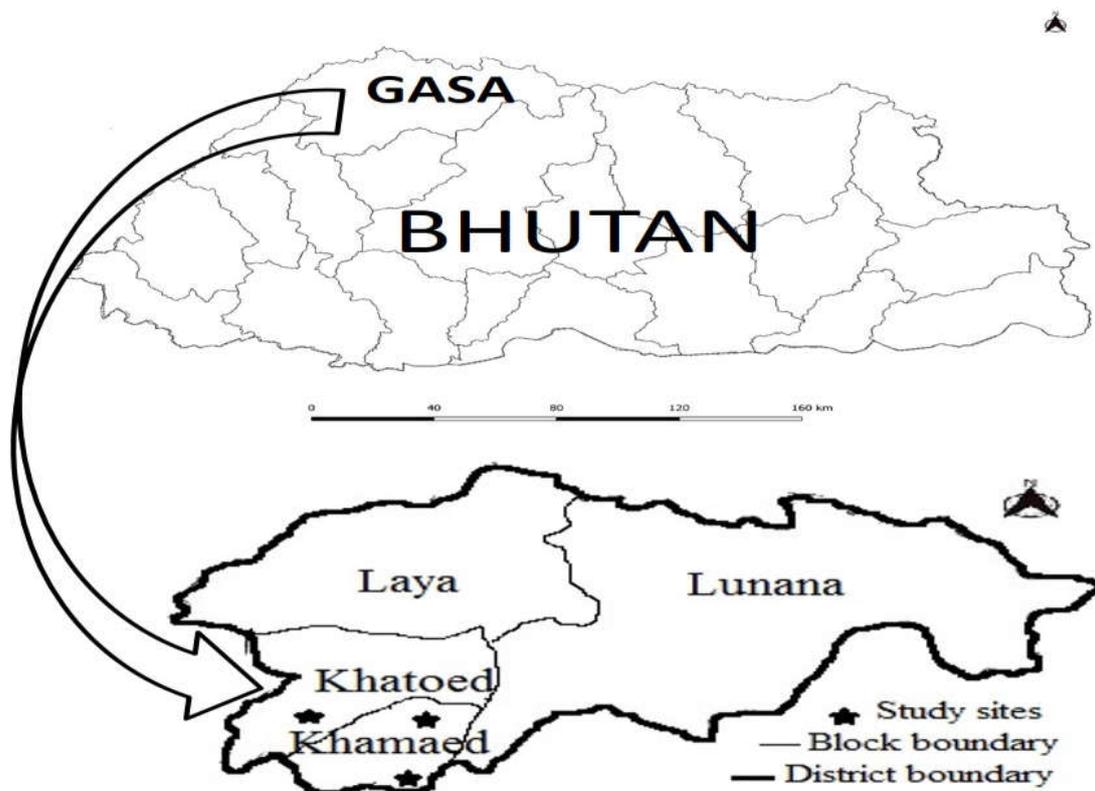


Fig. 1. Gasa, the location for study sites

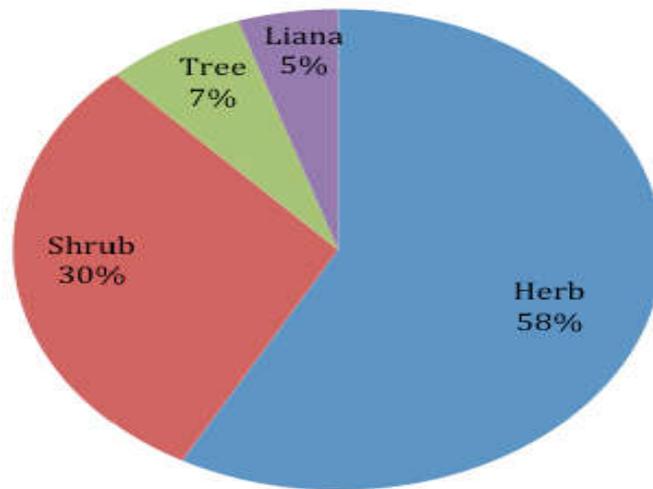


Fig. 2. The proportion of life form occurred in wetland vegetation

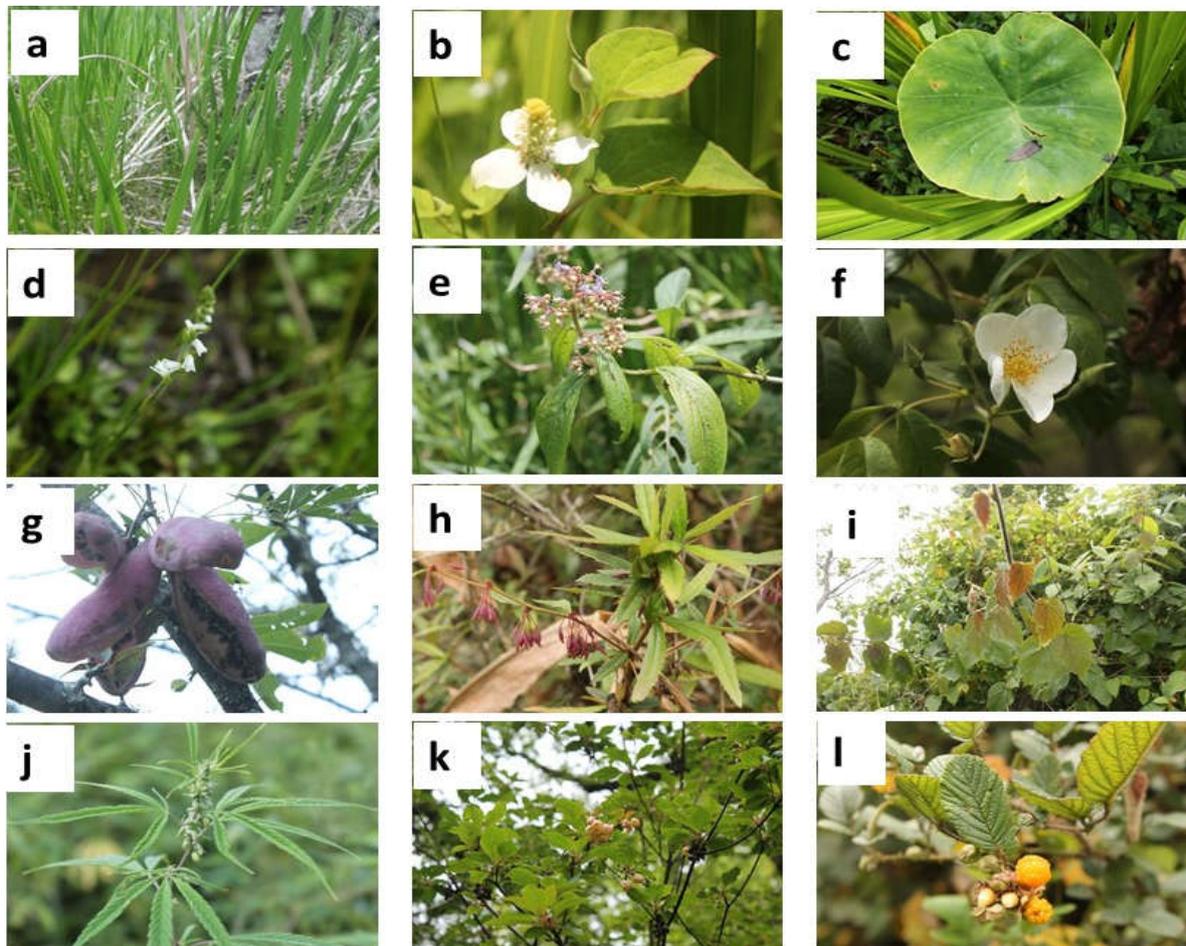


Fig. 3. Representative medicinal plants in wetlands: (a) *Acorus calamus* L., (b) *Houttuynia cordata* Thunb., (c) *Colocasia esculenta* (L.) Schott, (d) *Spiranthes sinensis* (Pers.) Ames (e) *Dichroa febrifuga* Lour., (f) *Rosa brunonii* Lindl. (g) *Holboellia latifolia* Wall., (h) *Berberis aristata* DC. (i) *Rubus paniculatus* Sm., (j) *Cannabis sativa* L., (k) *Enkianthus deflexus* (Griff.) C.K. Schneid., (l) *Rubus ellipticus* Sm

Table 1. List of medicinal plants occurred in wetland vegetation of Gasa, Bhutan

Sl. No.	Scientific name	Family	Life form	Part use	Medicinal uses
1	<i>Acorus calamus</i> L.	Acoraceae	Herb	Rhizome/shoot	Used in fever, constipation, bronchitis, cough, diarrhea, dysentery, piles [28], asthma, digestive problems (gas, bloating, colic) [29], nervine, [30], eupeptic, allay indigestion [15], scabies, fracture, edema and goiter dislocations [23]
2	<i>Ageratina adenophora</i> (Spreng.) R.M. King & H. Rob.	Asteraceae	Shrub	Leaf	Used to cure cut and fever [31]
3	<i>Ainsliaea latifolia</i> (D. Don) Sch. Bip.	Asteraceae	Herb	Root	Used in digestive problem i.e., colic [32]
4	<i>Alnus nepalensis</i> D. Don	Betulaceae	Tree	Leaf/branch	Reduces swelling and prevent sweating [15].
5	<i>Arisaema flavum</i> (Forssk.) Schott	Araceae	Herb	Bulb	Used in chronic tracheitis, bronchitis, tetanus, epilepsy, and skin diseases [32].
6	<i>Artemisia indica</i> Willd.	Asteraceae	Herb	leaf/ young shoot	Used to treat fever, cut, scabies, anthelmintic [31], vomiting, dizziness, high blood pressure, headache and skin diseases [33]
7	<i>Aster neoelegans</i> Grierson	Asteraceae	Herb	whole plant/ aerial parts	Reduces fever arising from poisoning and heals wounds, mumps and body swelling [7,34].
8	<i>Astilbe rivularis</i> Buch.-Ham. ex D. Don	Saxifragaceae	Herb	leaf/root	Used for blood purification, toothache [32], tonic, diarrhea, dysentery [31], body ache, sprain and post-partum recovery [33].
9	<i>Berberis aristata</i> DC.	Berberidaceae	Shrub	root/bark	Used in eye diseases, diarrhea, jaundice, skin diseases, syphilis, chronic rheumatism, urinary disorders, diabetes, jaundice, gastrointestinal problem [29,35], malaria fever, in relieving pyrexia, as a wash for ulcer sores, as an eye lotion in conjunctivitis [36,37], allays chronic cough and cold [15,34].
10	<i>Cannabis sativa</i> L.	Cannabaceae	Herb	leaf/flower/seed	Used in bronchitis, cuts, dyspepsia, skin disorders, cold, cough, epilepsy, sores [28], stomach disorders [15], diarrhea and headache [31].
11	<i>Centella asiatica</i> (L.) Urb.	Apiaceae	Herb	whole plant/leaf/root	Used for mental peace, as a blood purifier, for skin diseases [37], to treat cuts [15], nervine tonic, anti-ulcerative [30], heat sickness, to improve memory and diuretic [31].
12	<i>Cirsium falconeri</i> (Hook. fil.) Petr.	Asteraceae	Herb	-	Used as medicinal plant [15]
13	<i>Coelogyne stricta</i> (D. Don) Schltr.	Orchidaceae	Herb	Pseudobulb	Used for headache and fever [38].
14	<i>Colocasia esculenta</i> (L.) Schott	Araceae	Herb	leaf/rhizome	Used for fever and cough [15,39].
15	<i>Commelina diffusa</i> Burm. f.	Commelinaceae	Herb	stem /leaf	Treatment of abscess, boils, malaria, for treatment of insect, snake and bug bites, edema, laryngitis, sore throats, acute tonsillitis, otitis media, in nose bleeding [40], boils, burns, and itches [11,39].
16	<i>Commelina paludosa</i> Blume	Commelinaceae	Herb	whole plant	Used in treatment of sexual impotency [29].
17	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Asteraceae	Herb	whole plant	Stops wound bleeding and cure headache [15].
18	<i>Cymbidium iridioides</i> D. Don	Orchidaceae	Herb	Leaf	Used in blood clotting in deep wounds [38].

SI. No.	Scientific name	Family	Life form	Part use	Medicinal uses
19	<i>Cynoglossum lanceolatum</i> Forssk.	Boraginaceae	Herb	Aerial parts/leaf/stem	Used in cold sores, afts, headache [41] and chest [42]
20	<i>Daphne bholua</i> Buch.-Ham. ex D. Don	Thymelaeaceae	Shrub	bark/root/seed	To treat fever [15] and to expel intestinal worms [43]
21	<i>Dendrobium fimbriatum</i> Hook.	Orchidaceae	Herb	Whole plant	Used in liver upsets and nervous debility [38].
22	<i>Dichroa febrifuga</i> Lour.	Hydrangeaceae	Shrub	shoot/root	To prepare a febrifuge (anti-fever) [19,15], and to cure fever [31].
23	<i>Dipsacus inermis</i> Wall.	Caprifoliaceae	Herb	Root/leaf	Used as medicine [6]
24	<i>Drynaria propinqua</i> (Wall. ex Mett.) Bedd	Polypodiaceae	Herb	stem/rhizome	Used in fracture [31], antidote, detoxifier, and poisoning [44,15]
25	<i>Dryopteris juxtaposita</i> Christ	Dryopteridaceae	Herb	leaf	Used to cure chest and intestinal problems [42].
26	<i>Elsholtzia fruticosa</i> (D. Don) Rehder	Lamiaceae	Shrub	leaf/seed	To treat headache and anodyne [32].
27	<i>Enkianthus deflexus</i> (Griff.) C.K. Schneid.	Ericaceae	Shrub	Twig	To relieve gastric and indigestion problems [45]
28	<i>Erythrina arborescens</i>	Fabaceae	Tree	Seed/bark	Used to treat dysentery [31], febrifuge for kidney disorders, urine infection, back pain, giddiness, and disabilities [44].
29	<i>Fragaria nubicola</i> (Hook. f.) Lindl. ex Lacaita	Rosaceae	Herb	Whole plant/fruit	Anthelmintic and heals neurological and chest infections, and lung inflammation [34,6]
30	<i>Galium aparine</i> L.	Rubiaceae	Herb	whole plant/aerial parts	Used for migraine, sinusitis, jaundice [1], aperients and diuretic [46].
31	<i>Gaultheria nummularioides</i> D. Don	Ericaceae	Shrub	leaf/fruit	Antiseptic, carminative and neural stimulant [32].
32	<i>Geranium procurrens</i> Yeo	Geraniaceae	Herb	Root	Useful for cough and cold, bronchitis, the swelling of limbs, antidiarrheal, antitoxin and antimalarial [34]
33	<i>Girardinia diversifolia</i> (Link) Friis	Urticaceae	Herb	leaf/twig/bark	Useful to treat gonorrhoea [32,15], diabetes, fibre and fracture [31].
34	<i>Halenia elliptica</i> D. Don	Gentianaceae	Herb	Aerial parts	Heals wounds, allays common cough & cold, and headaches caused by the disturbances in blood and bile [7].
35	<i>Hedera nepalensis</i> K. Koch	Araliaceae	Liana	whole plant	Stimulant, diaphoretic, cathartic, rheumatism and emmenagogue [32]
36	<i>Holboellia latifolia</i> Wall.	Lardizabalaceae	Liana	fruit	Used for treating rheumatism [15].
37	<i>Houttuynia cordata</i> Thunb.	Saururaceae	Herb	Whole plant/root	Used against dysentery/diarrhea [15], indigestion and skin diseases [31].
38	<i>Hydrocotyle sibthorpioides</i> Lam.	Araliaceae	Herb	leaf	Used against dysentery, diarrhea, piles, rheumatism, digestive [29], and treating urinary problems [11].
39	<i>Impatiens arguta</i> Hook. f. & Thomson	Balsaminaceae	Herb	Leaf	Used to treat old wounds [43]
40	<i>Impatiens racemosa</i> DC	Balsaminaceae	Herb	Seed/fruit	Used to cure cold and cough [32].
41	<i>Jasminum humile</i> L.	Oleaceae	Shrub	Leaf /bark /fruit	Used in wounds [31], sinus and skin disorders [32].

SI. No.	Scientific name	Family	Life form	Part use	Medicinal uses
42	<i>Juglans regia</i> L.	Juglandaceae	Tree	whole plant/nut/bark/b ranch	Used for cleaning of teeth, applied on teeth during pain, valuable for enhancing the memory [36], used against diabetes [47], anthelmintic [31], heals air disorders such as headache, nausea, blurred vision [15]
43	<i>Ligustrum confusum</i> Decne.	Oleaceae	Shrub	leaf	Used as diuretic [21].
44	<i>Lyonia ovalifolia</i> (Wall.) Drude	Ericaceae	Shrub	stem/leaf	Used to treat boils, pimples, skin eruptions, worms, wounds [32], and scabies [31].
45	<i>Mahonia nepalensis</i> DC.	Berberidaceae	Shrub	stem/wood	Used for the treatment of skin diseases like eczema and psoriasis [48]
46	<i>Nasturtium officinale</i> W.T. Aiton	Brassicaceae	Herb	Leaf /whole plant	Used for the treatment of allergic problems and as diuretic, tonic to recover health and strength [49], constipation, goiter and vermifuge [32].
47	<i>Oenanthe javanica</i> (Blume) DC.	Apiaceae	Herb	Leaf /aerial parts	Used in anti-diabetic, anti-arrhythmic, anti-inflammatory, neuroprotective, alcohol detoxification, anti-toxic, anti-coagulant, hepatoprotective, anti-HBV and memory improvement [50]
48	<i>Parochetus communis</i> Buch.-Ham. ex D. Don	Fabaceae	Herb	leaf	Used for stomach disease of babies, and earache [32].
49	<i>Persicaria nepalensis</i> (Meisn.) H. Gross	Polygonaceae	Herb	whole plant	Used against swelling in the body parts [32].
50	<i>Pieris formosa</i> (Wall.) D. Don	Ericaceae	Shrub	Leaf/twig	Used to treat irritating skin diseases, however, extract of leaves & twigs are highly poisonous to people and local animals [43].
51	<i>Plantago erosa</i> Wall.	Plantaginaceae	Herb	seed/root/leaf	Used against diarrhea [51], bone fracture, and inflammation [32]
52	<i>Potamogeton crispus</i> L.	Potamogetonaceae	Herb	whole plant	Used as diuretic and treatment of urinary tract infections [50].
53	<i>Primula denticulata</i> Sm.	Primulaceae	Herb	Flower/ leaf	Used to treat diabetes, urinary ailments [32] and eye infections [42].
54	<i>Prinsepia utilis</i> Royle	Rosaceae	Shrub	fruit/root	Used against burns, cuts and rheumatic [32].
55	<i>Prunella vulgaris</i> L.	Lamiaceae	Herb	whole plant	To treat breath problems, lung complaints, liver & cerebral complaints, cold, fever, gastric complaints and headache [32,6].
56	<i>Quercus griffithii</i> Hook.f. & Thomson ex Miq.	Fagaceae	Tree	Nut	Used against diarrhea [15]
57	<i>Ranunculus diffusus</i> DC	Ranunculaceae	Herb	whole plant/leaf	Used to treat skin infection [52] and boils [32].
58	<i>Rhododendron arboreum</i> Sm.	Ericaceae	Shrub	Flower/ leaf	Used to treat mental retardation, dysentery, headache, eye cataract, wounds, rheumatism [53,31,32], diarrhea [15], and heart problems [36].
59	<i>Rosa brunonii</i> Lindl.	Rosaceae	Shrub	Root	Used to relief pain [32].
60	<i>Rosa sericea</i> Lindl.	Rosaceae	Shrub	flower	Useful for bile and air related disorders [7,19].

Sl. No.	Scientific name	Family	Life form	Part use	Medicinal uses
61	<i>Rubus biflorus</i> Buch.-Ham. ex Sm.	Rosaceae	Shrub	stem without bark	Useful for reducing blood pressure, common cold, and pleural effusion [7].
62	<i>Rubus ellipticus</i> Sm.	Rosaceae	Liana	fruit/shoot/root/bark	Used in treatment of fevers, diarrhea [48], gastric troubles, dysentery, colic, coughs [15], sore throat, skin diseases, wounds, tumors, cholera [36], jaundice, typhoid [31] and has antioxidant properties [29].
63	<i>Rubus paniculatus</i> Sm.	Rosaceae	Liana	fruit	Used against diarrhea and stomach disorders [32]
64	<i>Rumex nepalensis</i> Spreng.	Polygonaceae	Herb	leaf/root/twig	Used in treatment of colic, headache [47], skin diseases, wound healing and anti-allergic properties [29], against hair loss [15], boils, diuretic, purgative, scurvy and swelling of muscle [32].
65	<i>Scurrula elata</i> (Edgew.) Danser	Loranthaceae	Shrub	leaf	Reduce galls [31].
66	<i>Spiranthes sinensis</i> (Pers.) Ames	Orchidaceae	Herb	Root/stem	Used in curing sores [38].
67	<i>Strobilanthes auriculata</i> Nees	Acanthaceae	Shrub	Inflorescence	To increase stamina and immunity against diseases [54]
68	<i>Swertia bimaculata</i> (Siebold & Zucc.) Hook. f. & Thomson ex C.B. Clarke	Gentianaceae	Herb	Leaf	Used for the treatment of stomach disorders [43].
69	<i>Taxus baccata</i> L.	Taxaceae	Tree	leaf/bark/ axil	Used against asthma, bronchitis, lumbago, indigestion, cancer [53], cough [36], swelling, contraceptive [32] and as medicine [17]
70	<i>Thalictrum foliolosum</i> DC.	Ranunculaceae	Herb	Root	Used to treat abdominal pain, blood purification, boils, earache, eczema, eye diseases, fever, leucoderma, piles, rheumatism, gout, tonic and toothache [32,18]
71	<i>Trifolium repens</i> L.	Fabaceae	Herb	whole plant	Used against dandruff [32].
72	<i>Vaccinium dunalianum</i> Wight	Ericaceae	shrub	Leaf	Used to treat intestinal worms [43]
73	<i>Viburnum mullaha</i> Buch.-Ham. ex D. Don	Adoxaceae	Shrub	leaf/fruit	Used to treat stomachache and stimulant [32]
74	<i>Zanthoxylum acanthopodium</i> DC.	Rutaceae	shrub	Leaf/fruit/twig	Used externally to relieve abdominal pain and to relieve indigestion problems [45]

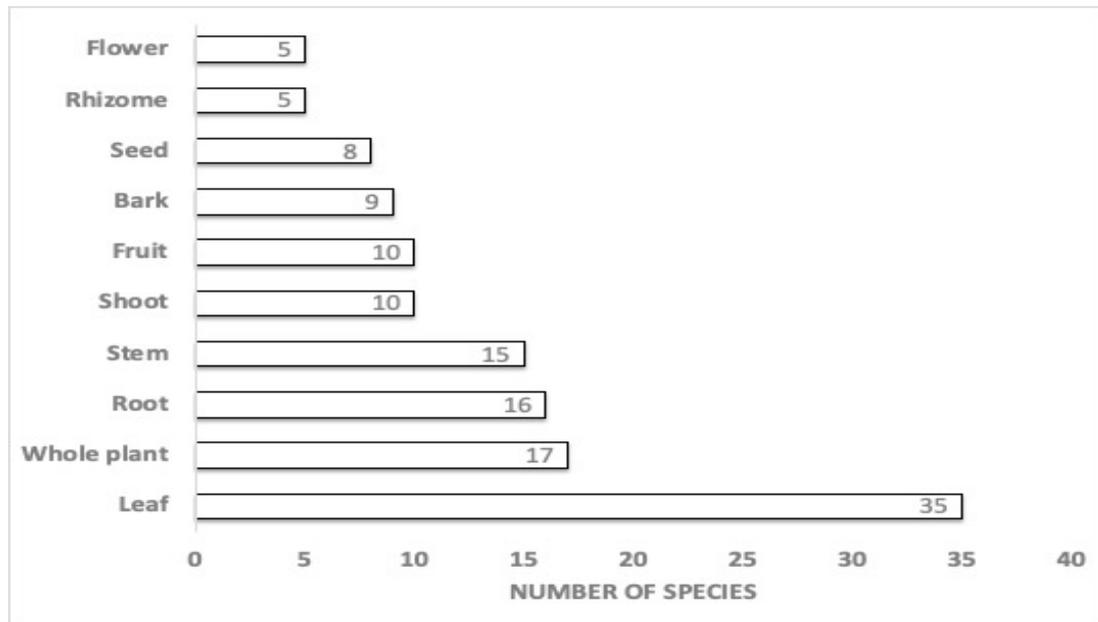


Fig. 4. Proportion of plant parts used for medicine

Table 2. Category of diseases that could be treated by medicinal plants in wetlands of Gasa, Bhutan

Sl.no.	Category of disease	Common diseases/problems	No. of species counted	% of species counted
1	Digestive diseases	Dysentery, constipation, colic, tetanus, dyspepsia, aperients, vermifuge, diarrhea, anthelmintic and eupeptic	47	20.2
2	Skin diseases	Scabies, boils, wounds, cut, abscess and sore	35	15.0
3	Respiratory diseases	Bronchitis, lungs problem, cough and cold, throat problem and tracheitis	24	10.3
4	Weather sickness	Fever, headache, sickness, flu, malaria, anodyne and migraine	23	9.9
5	Neurological diseases	Nervine, epilepsy, dizziness and stimulants	17	7.3
6	Tonic	Kidney, liver, heart, blood, health, oedema, blood clotting and sinus	16	6.9
7	Kidney diseases	Diabetes, diuretic and urinary disorders	16	6.9
8	Ear, nose and ear (ENT) diseases	Red eye/conjunctivitis, nose bleeds, jaundice and otitis	13	5.6
9	Osteoarthritis diseases	Joint pains, arthritis, fracture, mumps, sprains and rheumatism	13	5.6
10	Detoxification	Food allergy, insect allergy, poisoning and antidote	9	3.9
11	Stomach diseases	Stomach pain, ulcers, colonic problems	8	3.4
12	Hot diseases in body	Heat sickness, burns, inflammation and diaphoretic	6	2.5
13	Disease of mouth	Tooth decay and halitosis	3	1.2
14	Blood pressure diseases	High and low blood pressure	2	0.9
15	Disease caused by animal bites	Snake and insect bites	1	0.4

3.2 Medicinal Plants and their Usage

Almost every part of plants (leaf, bark, stem, shoot, flower, etc.) or sometime whole part is collected for the medicinal purposes. The three most plant parts used for medicine were leaf (47%), whole plant (23%) and root (22%) (Fig. 4), and this representation may differ on part usages [8]. The locally prepared drugs were regularly used and proven to be effective, cheap and beneficial with almost no side effect compared to the allopathic drugs [42]. The local population use indigenous knowledge to cure various diseases [42] and keep the practices intact through personal experiences and ancestral prescription [8]. Given the current trend of modernization, much of this knowledge is disappearing along with the traditional lifestyle and retreats of wetland [4]. Therefore, study of traditional knowledge on wetland medicinal plants is needed, while such knowledge still exists. This would enable the traditional medicine to complements the modern medicines adequately.

These wetland medicinal plant species were found effective against 15 categories of diseases (Table 2). Common diseases such as digestion (20.2%), skin (15%), respiratory (10.3%) and weather sicknesses (9.9%), were mostly treated which may be caused due to unhygienic practices at home. The use of medicinal plants against snake and insect bites were least (0.4%) represented, which may be due to collection difficulties or not able to identify these plants (Table 2). Uses of these medicinal plants against diseases varied from region to region. For instance, people of Rampur Ghol, Nepal use *Centella asiatica* (L.) Urb. for fever, diarrhea, and dysentery [11], while people of Kilikhar, Mongar, eastern Bhutan use it for hypertension and improving memory power [8]. The difference in the way medicinal plants are used for curing different diseases may be due to the local ethno-botanical practices and the prevalence of endemic diseases in the specific localities.

Species such as *Acorus calamus* L. is found richly in shallow fresh marsh of Bhutan [13]. However, it is vulnerable in Himachal Pradesh [54,55,26]. Similarly, the *Thalictrum foliolosum* DC species occurred in wetlands of Bhutan but is considered endangered in Himachal Pradesh, India [55]. The reasons may be due to lack of awareness of its uses by Bhutanese people and over harvesting in India, respectively. The root, rhizome, bark and shoot of these species were found to be effective against many diseases

(Table 2). This may encourage illegal, unsustainable and irrational non-scientific harvesting method like uprooting whole plant and potentially causing extinction. To preserve such invaluable wetland medicinal plants and integrate ethno-medicinal practices in our lives, sensitization on the uses of medicinal plants in their locality is recommended.

4. CONCLUSION

The wetland plants provide different ailments against different categories of diseases. Uses of medicinal plant parts differed according to the local communities and prevalence of endemic diseases. Families of medicinal plants such as Rosaceae, Ericaceae and Asteraceae were found dominant in the wetlands. In-depth study is recommended to explore other potentially important plants species in the wetlands in Bhutan. Our data may be useful for science education program in school or for species-level conservation measures by concerned agencies. Additionally, it may be useful for carrying out bioprospecting and phytochemical studies in future to formulate more traditional herbal remedies by ITMS and to add on to the list of the pharmacopoeia of Bhutanese traditional medicine. Thus, it is imperative for local communities, herbalist, park services and ITMS to collaborate for better planning and management of the wetland vegetation in Bhutan.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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