Ethnobotany of the genus *Elatostema* J.R. Forster & G. Forster (Urticaceae)

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Reviews and Mini reviews

Abstract

Background: Wild edible plants (WEP's) are used in various traditional systems all over the globe. WEP's are used as food, medicine, ornamental, forage and material purposes. *Elatostema* is one such genus that is used by many indigenous communities in Africa, Asia and Oceania. The objectives of this study are to provide ethnobotanical information about the non-stinging nettle genus *Elatostema*, to identify indigenous communities that use these species and to examine leaf area variation in species used by ethnic communities.

Methods: The data sets were collected from various online sources such as Research gate, Google Scholar and Academia.edu; print sources such as published articles in ethnobotanical journals and herbarium sources from various herbaria. The datasets were then segregated into four types (Consumption, medicinal, Forage and other) based on the recorded usage by indigenous communities all over the globe. We analyzed leaf variation with type of usage using density plots, Shapiro-Wilks test, Kruskal-Wallis test and Principal Component Analysis (PCA). The Use-Value (UV) of all species was also calculated using the number of recorded usage and their citations within the genus.

Results: This study documented 40 *Elatostema* species with recorded ethnobotanical usage. We record 30 indigenous communities that use species of *Elatostema* in their daily lives. After performing all the analysis (density plots, Shapiro-Wilks test, Kruskal-Wallis test and Principal Component Analysis) we found out that there is no significant variation in leaf area with the type of use. *Elatostema platyphyllum* Wedd. and *Elatostema sessile* J.R. Forster & G. Forster were found to have low values (UV=0.18 and UV=0.23) because of high recorded usage and citations.

Conclusion: This study illustrates diversity of *Elatostema* species used as food, medicine, forage and ornamental or material purposes by various indigenous communities in the world. The study disproves our hypothesis that the usage of an *Elatostema* species for a specific purpose (food, medicine, fodder, others) is related to leaf size, i.e., bigger the size of the leaves, more the chances of it to be used as food or forage. Results from our analyses shows that there is no variation in leaf area with the type of use. The documented ethnobotanical records of *Elatostema* species along with our personal observations in the field provided in this study would help in elucidating the importance of this genus as one of the main leafy wild edible plant for human consumption and will further promote applied research in this group.

Key words: Elatostema, Urticaceae, ethnobotany, Indigenous communities, Analysis

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Background

Human beings have been cultivating, growing and improving plants for their benefit and they collect certain species for their use. This relationship between human beings and plants is what forms the base for ethnobotany (Jain & Dam 1979). Plant species collected from the wild have become a major source of nutrition and medicine for many indigenous people (Heywood 2011). Their life is dependent on forest for access to natural plant wealth which provides them food and other materials required for their sustenance (Sundriyal *et al.* 1998; Arora & Pandey 1996; Albuquerque & Hanazaki 2009). Moreover, the usage of wild plants is an integral part of strong traditional and cultural systems which has been developed over generations (Sundriyal *et al.* 1998). Documenting indigenous knowledge of plants and their ethnobiological value is significant to study human plant relationships, conservation and utilization of biological resources (Pradhan & Badola 2008; Pieroni *et al.* 2011). The wild edible plants especially the ones used as leafy vegetables makes significant contribution in generation of income (Angami *et al.* 2006). The wild edible plants are considered as the most important part of the Non-timber Forest Products (NTFPs) and they play a major role in elevating the socio-economic status of tribal and ethnic communities (Maikhuri *et al.* 2004). In many studies *Elatostema* species have been recorded to be used as a non-timber forest product by various indigenous groups (Murtem & Chaudhry 2016a; Angami *et al.* 2006; Muthu & Rimo 2018; Srivastava & Nyishi 2010; Shrestha 2013; Konsam *et al.* 2016a).

While exploring wild plant species with potential for human consumption it is important to consider recorded ethnobotanical uses, their geographical occurrence and their morphology. These data help in asking relevant questions such as how many species are used by human beings and for what purposes, why only a specific species is used in an area and is the usage dependent on the morphology of the species (Miller *et al.* 2015).

Genus *Elatostema* J.R. Forster & G. Forster, of the family Urticaceae are usually herbs, sub- shrubs and rarely shrubs. It consists of about 500 species distributed in the tropical and Sub-tropical Africa, Asia, Oceania but is absent in the Neotropics (Qi *et al.* 2003; Wei *et al.* 2011; Tseng *et al.* 2019). The International Plant Name Index search shows 995 names for *Elatostema* complex which includes sectional and serial names. These plants grow luxuriantly in the tropical, sub-tropical and sub-temperate forests having an elevation between 500-2500m (Tseng *et al.* 2019). This genus is found to be most diverse on limestone karsts of South East Asia (Qi *et al.* 2003). The delimitation of this genus along with *Elatostematoides* C.B. Rob., *Procris* Comm. ex Juss. and *Pellionia* Gaudich. has been problematic since its inception (Hadiah *et al.* 2003; Hadiah & Conn 2009; Tseng *et al.* 2019; Wu *et al.* 2013).

Elatostema species are believed to be of a meagre economical usage which are used in combination with other plants for treating cough, flu, bowel movements, itching, etc. (Wei *et al.* 2011). Leaves of species like *Elatostema platyphyllum* Wedd., *E. sessile* J.R. Forst. & G. Forst. are consumed by many indigenous communities such as *Nyishi, Adi, Mao,* etc. in North-East India (Tshering *et al*. 2018; Murtem & Chaudhry 2016b; Pfoze *et al*. 2012; Sigdel *et al*. 2013; Yumnam *et al*. 2011; Ronald *et al*. 2019; Angami *et al*. 2006; Muthu & Rimo 2018; Srivastava & Nyishi 2010). The information regarding the number of species used by people from indigenous communities and their type of usage is scanty and scattered across various literature. This has led to few applied studies in this genus which focuses on disease management, anti-bacterial activity, nutraceutical properties and trace elements (Konsam *et al.* 2016b; Mariani *et al.* 2016; Reza *et al.* 2018; Santos *et al.* 2018; Hui 2019). In our study we provide a compilation of documented ethnobotanical records along with our personal observations in the field which we believe would help in elucidating the importance of this genus as a major wild edible plant for human consumption and will further promote applied research in this genus.

The objectives of this study are to (1) provide a global ethnobotanical data of the non-stinging nettle genus *Elatostema*, (2) to identify the indigenous communities across the globe that use these species for various purposes and (3) to assess if there is any significant difference in leaf area with type of usage (Human consumption, Medicinal use, Forage and Other use), i.e., if the species with bigger leaf areas were preferred more as food or fodder or species with smaller leaves were used more as medicine, etc.

Materials and Methods

Data collection

We collected data on usage of different plant parts by indigenous communities along with data on geographic distribution of the *Elatostema* species from herbarium specimens housed at CAL, ARUN, ASSAM, DD, BSHC, K, BM, NY, and P (Herbarium codes following Thiers 2016), (Table 1).

Table 1. Indigenous communities recorded in the study

From India		From other Countries	
Indigenous communities	**Region**	**Indigenous communities**	**Country**
Jaintia	Meghalaya	Melpa	PAPUA NEW GUINEA
Monpa	Arunachal Pradesh	Kaili Inde	INDONESIA
Nyishi	Arunachal Pradesh	Monpa	CHINA
Adi	Arunachal Pradesh	Chagga	TANZANIA
Mao	Manipur	Batak Toba	INDONESIA
Koki	Manipur	Chakma	BANGLADESH
Mizo	Mizoram	Han	CHINA
Angami	Nagaland	Lua	THAILAND
Karbi and Munda communities	Assam	Hani	CHINA
Apatani	Arunachal Pradesh	Siwai	INDONESIA
Limboo	Sikkim	Buin	INDONESIA
Tangkhul	Manipur	Ndumba	PAPUA NEW GUINEA
Cholanaikan	Kerala	Samawa community	INDONESIA
Miji	Arunachal Pradesh	Batak Simalungun	INDONESIA
Galo	Arunachal Pradesh	Kalam	PAPUA NEW GUINEA

We also noted the relevant data viz. location, date, collection number, collector, etc. Data from the field trips from December 2018 to March 2020 in North East India (Arunachal Pradesh, Meghalaya and Sikkim) were collected using informal interviews and a simple non-compulsory, open-ended questionnaire wherein the informants did not have to answer if they felt uncomfortable. The elders of different indigenous communities between the age groups of 45 to 65 years (village heads, foresters etc.) who frequently visited the forests were asked questions about the usage of *Elatostema* species in their daily lives. Local tribal markets were also visited to record plant usage. The voucher number of species collected during these tours are provided in Table 2. A literature review was undertaken to investigate, and document recorded uses of *Elatostema* species. We used various scientific literature sources such as Research Gate, Google scholar and Academia.edu and used keywords such as “Elatostema”, “Ethnobotany of Elatostema”, “uses of *Elatostema*” for searching relevant data on the usage of *Elatostema* species in the world. We reviewed (1) ethnobotanical studies carried out in the regions where *Elatostema* is recorded to occur and (2) studies on the usage of wild edible plants by various indigenous communities across the world. We consulted online ethnobotanical database *Plants for future* and scientific databases such as *JSTOR*, *Pubmed*, *Plants of the World online*, *Global Biodiversity Information Facility*, *International Plant Names Index* and *The Plant list* for information on *Elatostema* species. A map was prepared based on recorded ethnobotanical data of collected and documented species from various parts of the world (Figure 1).

Leaf area measurements

We examined herbarium specimens housed at Central National Herbarium (CAL), Kolkata that were collected from the locality from which the ethnobotanical data were recorded. Linear measurements were used for calculating leaf area of *Elatostema* species (Bhat & Chanda 2003). Herbarium specimens were also consulted online (K, BM, NY, and P) for specimens that were not found at CAL (Herbarium codes following Thiers 2016). The protologues of species with documented ethnobotanical usage were checked online using Biodiversity Heritage Library (BHL) for leaf dimensions when neither digital images nor physical specimens could be found.

In our study we recorded 40 species (Table 2) with documented ethnobotanical usage. Of these we could collect leaf area of 27 taxa that were identified up to the rank of species in various literary sources,13 taxa (not identified up to the rank of species in literary sources) were not used in leaf area measurements. We investigated three herbarium specimens per species and noted the range in leaf dimensions from 5-6 leaves per species and the average of these ranges were then used to calculate the area. We calculated leaf area using direct methods (linear measurement from leaves) and graph paper method.

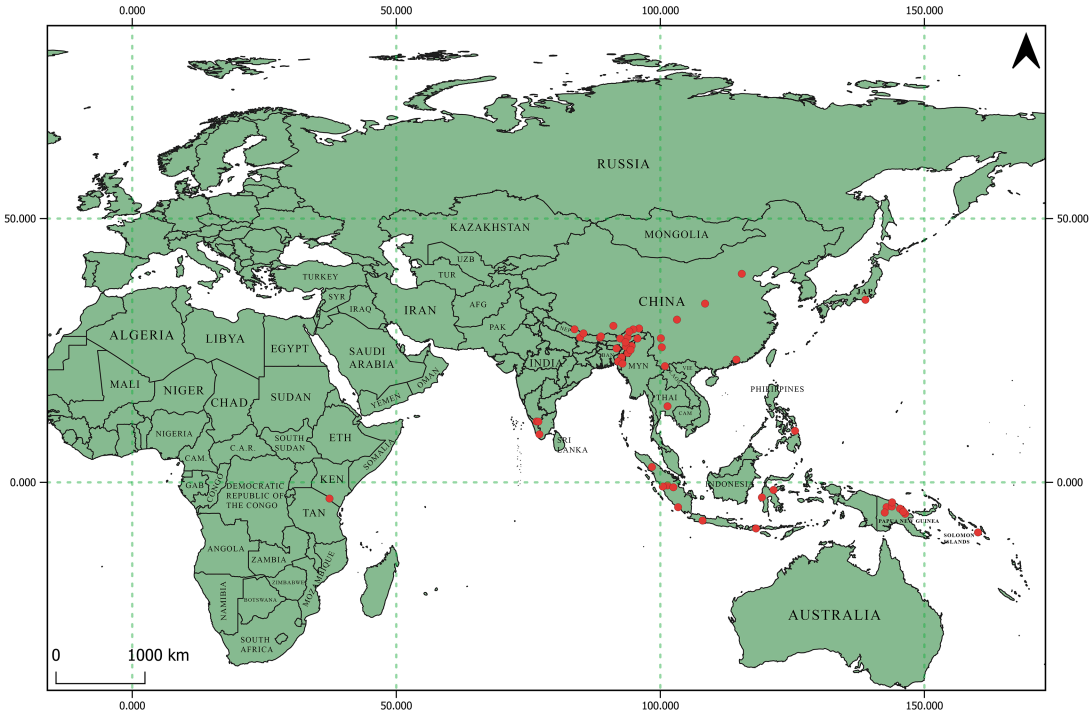

Figure 1. Geographic locations of species documented in this study. Collection sites determined by herbarium specimens and literature survey.

Data analysis

Ethnobotanical data were categorized as plant parts used, usage as food, medicinal uses, forage and others (ornamental, material uses etc.) The food category comprises of species that are used for human consumption; the medicinal category comprises of species used in varied forms for healing and therapeutical effects; the forage category comprises of species collected from the wild especially for feeding domesticated animals; finally, the others category comprises of species used for ornamentation, counter-magic and material purposes such as making ropes.

To assess if there is any significant difference in leaf area regarding type of use (Human consumption, Medicinal use, Forage, Other use) we used H0 (null hypothesis) and H1 (our hypothesis)

H0: There is no significant difference in leaf area regarding type of use.
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Our data set had two independent categorical variables (1. Use, 2. Status) and one dependent numerical variable (Leaf area). Variable use has four levels (Human-consumption, Medicinal-use, Forage, Other-use) and variable status has two levels (Recorded, Not-recorded). Groups in variable use (Human-consumption, Medicinal-use, Forage, Other-use) are treated as main groups and groups in variable status are treated as subgroups of the main. First the data was visually analyzed. Shapiro-Wilks test was performed to test normality. As all the data were found to be non-parametric, Kruskal-Wallis rank sum test was done for analyzing significant difference. For better understanding of how all parameters correlate and the data distribution Principal Component Analysis (PCA) was done. Statistical analysis and making of plots were done using R studio3.0.

Use-value (UV)

Ethnobotanical studies seek to identify important plant species for a given culture. In order to make conclusions about plant-human knowledge across cultures we must be able to measure ethnobotanical knowledge in a uniform way (Zenderland *et al.* 2019). Use-value index is widely used for the purpose of quantifying the importance of useful plants (Phillips & Gentry 1993). Formula given by Rossato *et al.* (1999) ($UV=\sum U_i/n$) is used for these studies. U_i is total number of uses recorded for a species while, n is total number of informants or frequency of citation. We used Use-Value Index across recorded categories (Food, Medicinal, Forage and Others) to find out the relation between number of recorded uses per species and their actual Use value in our datasets.

Table 2. Documentation of *Elatostema* species with recorded Ethnobotanical usage

Species	**Voucher numbers**	**Region**	**Indigenous communities**	**Local names**	**Parts used**	**Usage as food**	**Medicinal Uses**	**Used as forage**	**Others (Ornamental/ Material uses)**	**References**
Elatostema acuminatum (Poir.) Brongn.	71648	CHINA	**Han tribe**	Not mentioned	Leaves, fruits	Edible, used as leafy vegetable	Not mentioned	Not mentioned	Not mentioned	Ghorbani *et al.* 2012
Elatostema beccarii H. Schroet.	Not Collected	PAPUA NEW GUINEA	**Melpa tribe**	*Kengana*	Leaves	Not mentioned	Not mentioned	Not mentioned	Counter magic	Telban 1988
Elatostema cuneatum Wight	Not Collected	INDIA (Arunachal Pradesh)	**Monpa community**	*Chulukpa*	Leaves	Tender Leaves consumed as vegetable after proper leaching	Not mentioned	Not mentioned	Not mentioned	Plants for a Future (https://pfaf.org/); Tsering *et al*. 2017
Elatostema cuneiforme W.T. Wang	Not Collected	CHINA	**Monpa community**	*Tsen-tsen-pa*	Stem	Not mentioned	Not mentioned	Aerial parts used as forage	Stem used as rope or twine	Li *et al*. 2020
Elatostema dissectum Wedd.	71643	INDIA (Meghalaya, Arunachal Pradesh)	**Jaintia tribe**	*Jhur Khlow*	Leaves, Fruits	Raw or Young Leaves cooked	Not mentioned	Not mentioned	Not mentioned	Plants for a Future (https://pfaf.org/); Jain & Dam 1979; Jaiswal 2010
Elatostema ficoides Wedd.	Not Collected	INDIA(Sikkim)	Not mentioned	*Chiplu, Chiplay*	Not mentioned	Not mentioned	Ethnoveterinary medicine. 20-50gm plants crushed and given twice daily to lifestock to treat fever	Not mentioned	Not mentioned	Bharti & Sharma 2012
Elatostema heyneanum (Wedd.) Hallier f.	Not Collected	INDIA (Kerala)	**Cholanaikan tribe**	*Elaven*	Leaves	Not mentioned	Leaf juice is used for treating immunodeficiency in children and various liver diseases	Not mentioned	Not mentioned	Vilash *et al*. 2016; Kumar *et al*. 2019

Elatostema hookerianum Wedd.	71638	CHINA (Yunnan)	Not mentioned	*Kena, Shilikangquing*	Whole plant	Not mentioned	Not mentioned	Used as fodder to feed Mithun (Bos frontalis)	Not mentioned	Geng *et al*. 2017
Elatostema integrifolium (D. Don) Wedd.	71647	NEPAL (N.Lipe Jhar)	Not mentioned	Not mentioned	Root	Not mentioned	Juice of Root about 4 teaspoon is given 3 times a day in case of fever	Not mentioned	Not mentioned	Manandhar 1993
Elatostema involucratum Franch. & Sav.	Not Collected	CHINA	**Hani tribe**	*Luo bu, A bo*	Tender stem, Leaf	Potherb cooked like spinach	Not mentioned	Not mentioned	Not mentioned	Lou *et al*. 2019
Elatostema laetevirens Makino	Not Collected	CHINA, INDIA (Arunachal Pradesh)	**Monpa community**	Not mentioned	Leaves	Tender Leaves cooked as vegetable	Not mentioned	Not mentioned	Not mentioned	Plants for a Future (https://pfaf.org/); Tsering *et al*. 2017
Elatostema laevissimum W.T. Wang	Not Collected	CHINA (Yunnan)	Not mentioned	Not mentioned	Whole plant	Not mentioned	Not mentioned	Used as fodder to feed Mithun (Bos frontalis)	Not mentioned	Geng *et al*. 2017
Elatostema lineolatum Wight	71641	INDIA (Arunachal Pradesh, Nagaland, Manipur, Assam, Nilgiris)	**Monpa community** **Angami tribe** Manipur **Karbi-Anglong tribes**	*Dambe-hru* *Jothu, Gazo* *Ching sougri* *Himbu*	Shoots and leaves	Tender shoots and leaves used as vegetable; Boiled with rice to prepare Galho(an angami dish)	Paste of leaf applied on cuts caused by rocks stones or iron pieces	Not mentioned	Not mentioned	Tsering *et al*. 2017; Singh & Teron 2015; Konsam *et al*. 2016b; Borthakur 1976; Paulsamy *et al*. 2007

Elatostema longipes W.T. Wang	Not Collected	THAILAND	**Lua tribe**	Not mentioned	Leaves	Not mentioned	Used for treating diabetes	Not mentioned	Not mentioned	Phumthum & Balslev 2018
Elatostema macrophyllum Brongn.	Not Collected	INDONESIA (Sumbawa Island), PAPUA NEW GUINEA,	**Samawa community** Papua New Guinea	*telat* *Gidra*	stems, leaves	Eaten as vegetable; people eat plant ash as salt	Not mentioned	Not mentioned	Plant ash used as salt substitute	Rahayu & Rustiami 2017; Rugayah *et al*. 1989; Ohtsuka *et al*. 1987
Elatostema monandrum (Buch.-Ham. ex D.Don)H.Hara	71645	NEPAL (Langtang Village)	Not mentioned	Not mentioned	Roots	Not mentioned	Root paste is used to treat cuts and wounds	Not mentioned	Not mentioned	Shrestha 2015
Elatostema nasutum Hook.f.	71605	CHINA and in Yunnan	**Monpa community**	*Da-mi-ru*	Stem, Leaves	Leaves used as vegetable which is first boiled in water before consumption	Not mentioned	Used as fodder to feed Mithun (Bos frontalis)	Stem used as rope or twine	Li *et al*. 2020; Geng *et al*. 2017
Elatostema paivaeanum Wedd.	Not Collected	TANZANIA (Kilimanjaro)	**Chagga**	*nzunga, isunguwala, lya muringrni*	Not mentioned	Not mentioned	gastro-intestinal remedies	Not mentioned	Not mentioned	Hemp 1999
Elatostema papillosum Wedd.	71617	BANGLADESH (Hill tracts)	**Chakma tribe**	Not mentioned	Stems and Leaves	Not mentioned	Extract of stems and leaves is given to drink for treating hysteria, abdominal pain	Not mentioned	Not mentioned	Rahman *et al.* 2007
Elatostema parasiticum Blume ex H. Schroet.	Not Collected	INDONESIA	**Siwai and Buin tribe**	Not mentioned	Not mentioned	Not mentioned	Used for treating fever, shows anti-microbial activity	Not mentioned	Not mentioned	Mariani *et al.* 2016; Stefan & Birsa 2019
Elatostema parvum (Blume)Blume ex Miq.	73752	INDIA (Assam)	**Karbi and Munda communities**	*Longle mehek*	Leaves	Young leaves are eaten with pulses	Not mentioned	Not mentioned	Not mentioned	Borah *et al*. 2020
Elatostema platyphyllum Wedd.	71640	INDIA (Arunachal Pradesh, Assam, Sikkim);	**Nyshi tribe** **Galo tribe** **Adi tribe** **Apatani tribe**	*Huj* *Hoj Ao* *Sakobadha* *Hiipe*	Roots, Leaves, Whole plant	Leaves used as vegetable,	Roots juice used for inducing vomiting; Paste of leaves applied on	Whole plant is used as forage to	Not mentioned	Murtem & Chaudhry 2016a; Murtem & Chaudhry 2016b;

		CHINA (Yunnan), INDONESIA, NEPAL	**Karbi tribe** **Limboo tribe** CHINA (Yunnan) NEPAL	*Tengup/Tangnap* *Gagleto* *Zhemeng* *Sano gangleto*		Boiled before consumption	cuts caused by rocks; One teacup of leaf decoction in water is taken for five days to treat dysentery	feed Mithun (Bos frontalis)		Kar & Borthakur 2007; Srivastava & Adi 2009; Yumnam *et al*. 2011; Kala 2005; Geng *et al*. 2017; Yakang *et al*. 2013; Badola & Pradhan 2013; Srivastava & Nyishi 2010; Borthakur 1976 ; Nyitan & Das 2018; Tag *et al*. 2012; Rinya *et al*. 2020; Shrestha 2013; Jha 2015
Elatostema rostratum (Reinw. ex Blume) Hassk.	Not Collected	INDONESIA (West Java)	Not mentioned	*Uuyahan*	Not mentioned	Plants used as food	Not mentioned	Not mentioned	Not mentioned	Harada 2004
Elatostema rupestre (Buch.-Ham. ex D. Don) Wedd.	71646	INDIA (Mizoram)	Not mentioned	Not mentioned	Leaves	Leaves eaten with rice	Not mentioned	Not mentioned	Not mentioned	Lalmuanpuii 2018
Elatostema sessile J.R. Forst. & G. Forst.	73735	INDIA (Arunachal Pradesh, Manipur, Mizoram, Nilgiris), NEPAL	**Nyishi tribe** **Monpa Community** **Adi tribe** **Miji tribe** **Mao tribe** **Koki tribe** **Mizo tribe** NEPAL	*Tatomung, Hopi-hojap* *Fambe Che, Jooke* *Obur* *Panplo* *Edeiovu* *Solunche* *Dawh-van-nei* *Gagleto*	Leaves	Tender leaves consumed as vegetable, Shoots boiled and eaten by Mizos	Poultice of leaves used for Abdominal disorders, curing body pain; Plant paste used on boils, pimples and blisters	Used as fodder	Whole plant Considered as frog poison by Nyishi	Anonymous 1952; Pal 1984; Tsering *et al.* 2017; Tshering *et al*. 2018; Murtem & Chaudhry 2016a; Pfoze *et al*. 2012; Sigdel *et al*. 2013; Yumnam *et al*. 2011; Ronald *et al*. 2019; Angami *et al*. 2006;

										Muthu & Rimo 2018; Srivastava & Nyishi 2010; Kar *et al*. 2013; Paulsamy *et al*. 2007; Gewali 2008; Shrestha 2013; Saha & Sundriyal 2013
Elatostema strigosum Hassk.	Not Collected	INDONESIA (North Sumatra)	**Sub-ethnic Batak Simalungun**	*Sisik naga*	Leaves, fruits	Not mentioned	Used for treating hypertension, Injury, Gastrointestinal disorders and fever	Not mentioned	Not mentioned	Silalahi *et al*. 2015; Purba *et al*. 2016
Elatostema umbellatum (Siebold & Zucc.) Blume	Not Collected	JAPAN (Irouzaki)		*Uwabamiso*	Not mentioned	Food. Used as side dish	Not mentioned	Not mentioned	Not mentioned	Wiley *et al*. 2019
Elatostema sp 1.	Not Collected	INDONESIA (Central Sulawesi)	**Kaili Inde tribe**	*Pedura walehu*	Not mentioned	Not mentioned	Skin disease	Not mentioned	Not mentioned	Fathurrahman *et al*. 2016
Elatostema sp 2.	Not Collected	PAPUA NEW GUINEA (East Sepik Province)	Not mentioned	*Kaskas-Bhirs*	Not mentioned	Not mentioned	Scabies	Not mentioned	Not mentioned	Koch *et al*. 2015
Elatostema sp 3.	Not Collected	PAPUA NEW GUINEA (East Sepik Province)	Not mentioned	*Moin Kukuri*	Not mentioned	Not mentioned	Fever, Headache, Joint Pain, Fertility	Not mentioned	Not mentioned	Koch *et al*. 2015
Elatostema sp 4.	Not Collected	SUMATRA (Samosir district)	**Batak Toba community**	*Aup-Aup*	Not mentioned	Not mentioned	Medicinal	Not mentioned	Not mentioned	Ibo & Arimukti 2019
Elatostema sp 5.	Not Collected	INDIA (Manipur-Ukhrul district)	**Tangkhul tribe**	*Hantekhan*	Leaves	Cooked with meat or dry fish	Not mentioned	Not mentioned	Not mentioned	Salam *et al*. 2012
Elatostema sp 6.	Not Collected	Papua New Guinea	**Ndumba Tribe**	*Merura*	Leaves	Not mentioned	Leaves eaten as medicine		Leaves used as	Hays 1980

									ornamentation by women	
Elatostema sp 7.	Not Collected	Papua New Guinea	**Ndumba Tribe**	*Nronggaaria ara*	Leaves	Not mentioned	Leaves eaten as medicine	Leaves fed to pigs to incraese their body fat	Leaves eaten on ceremonies	Hays 1980
Elatostema sp 8.	Not Collected	INDONESIA (Sumatra)	Not mentioned	*Kerih*	Leaves	Not mentioned	Leaves used in fever	Not mentioned	Not mentioned	Silalahi *et al.* 2018
Elatostema sp 9.	Not Collected	INDONESIA (Sumatra)	Not mentioned	*Komil*	Leaves	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Silalahi *et al.* 2018
Elatostema sp 10.	Not Collected	Papua New Guinea (Kalam, Upper Kaironk valley)	**Kalam People**	*Gangal*	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Used for beauty magic	Gardner 2010
Elatostema sp 11.	Not Collected	Papua New Guinea (Kalam, Upper Kaironk valley)	**Kalam People**	*Sspi-lum-ket*	Not mentioned	Not mentioned	Not mentioned	Not mentioned	worn in belt and arm belts as decoration	Gardner 2010
Elatostema sp 12.	Not Collected	Papua New Guinea (Kalam, Upper Kaironk valley)	**Kalam People**	*Yuley*	Shoots	Shoots eaten raw	Not mentioned	Not mentioned	Foliage used in beauty magic	Gardner 2010
Elatostema sp 13.	Not Collected	Solomon Islands	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Plants thought to give life, health and strength by Islanders	Not mentioned	Not mentioned	Tedder & Tedder 1979

Data analysis

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Use-value (UV)

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Results

Ethnobotanical analysis of Elatostema species

We identified 30 indigenous communities from all over the globe that use *Elatostema* species. From India 15 indigenous communities were recorded and 15 were recorded from other countries. One indigenous community, *Monpa* was seen to exist both in India and China (Table 1).

Of the ca. 500 *Elatostema* species in the world, we identified 40 taxa that have documented ethnobotanical usage (Table 2). For human consumption 16 species were used, 20 species were used for medicinal purposes, seven species were used as forage and ten species had varied (ornamental/material) usage. We observed that most of the documented species had their native ranges in South Asia, East Asia and South East Asia (Table 3) which corresponds with the fact that the center for diversity of *Elatostema* species is towards these regions (Hadiah *et al.* 2003; Hadiah & Conn 2009; Wei *et al.* 2011; Wu *et al.* 2013; Tseng *et al.* 2019).

Five indigenous communities use more than one *Elatostema* species. *Monpa*-Arunachal Pradesh (4 species), *Kalam*- Papua New Guinea (3 species), *Nyishi*- Arunachal Pradesh (2 species), *Adi*- Arunachal Pradesh (2 species) and *Ndumba*- Papua New Guinea (2 species). Moreover, four species (*Elatostema sessile* J.R. Forster & G. Forster, *Elatostema lineolatum* Wight, *Elatostema platyphyllum* Wedd. and *Elatostema macrophyllum* Brongn.) in our studies were used by more than one indigenous group.

Elatostema species used as medicine

The most common Ethnobotanical usage of *Elatostema* species in our study is as medicine. In our study 20 *Elatostema* species were used as medicine (Table 2). Extracts from stems and leaves, leaf decoction and poultice of leaves of five species viz. *E. sessile*, *E. platyphyllum*, *E. papillosum*, *E. paivaeanum* and *E. strigosum* were used to treat gastrointestinal disorders and abdominal pain by indigenous communities in India, China, Indonesia, Nepal, Tanzania and Bangladesh (Table 2). Six species viz. *E. integrifolium E. strigosum*, *E. parasiticum*, *E. ficoides*, *E. sp.* 3 and *E. sp.* 6 were used to treat fever. Paste of leaves and stem of three *Elatostema* species viz. *E. lineolatum*, *E. platyphyllum* and *E. monandrum* were used to treat cuts and wounds caused by rocks and iron pieces.

Plant paste of *E. sessile* was used to treat boils, pimples and blisters by *Nyishis*, *Monpas and Adis* of

Arunachal Pradesh, India. Extracts of stems and leaves of *E. papillosum* were used to treat hysteria by *Chakma* in Bangladesh. Leaves of *E. strigosum* were used in treating hypertension by *Batak Simalungun* in Indonesia. *E. longipes* was recorded to be used in treating diabetes by *Lua* community in Thailand (Phumthum & Balslev 2018). Leaf juice of *E. heyneanum* were used for treating immunodeficiency in children. *E. sp. 13* of Solomon Islands was recorded to give life, health and strength to Islanders (Tedder & Tedder 1979).

In many cases such as *E. paivaeanum*, *E. strigosum, E. longipes, E. parasiticum, E. sp.* 1, *E. sp.* 2, *E. sp.* 3, *E. sp.* 4, *E. sp.* 6, *E. sp.* 7, *E. sp.* 8, and *E. sp.* 13 recorded for medicinal usage in our study there were no description of preparation methods. We recorded 15 species in our study that had exclusive medicinal usage (no food, forage and other uses recorded).

Table 3. Native ranges of recorded *Elatostema* species. Data collected from POWO (Plants of the world online) and recorded localities in published reports.

Species	**Native range**
Elatostema dissectum Wedd.	South Asia, East Asia
Elatostema cuneatum Wight	South Asia, East Asia, South East Asia
Elatostema laetevirens Makino	East Asia
Elatostema sessile J.R. Forst. & G. Forst.	South Asia, East Asia, South East Asia
Elatostema integrifolium (D. Don) Wedd.	South Asia, East Asia, South East Asia
Elatostema lineolatum Wight	South Asia, East Asia, South East Asia
Elatostema beccarii H.Schroet.	Papua New Guinea, Solomon Islands
Elatostema platyphyllum Wedd.	South Asia, East Asia, South East Asia
Elatostema cuneiforme W.T. Wang	East Asia
Elatostema nasutum Hook.f.	South Asia, East Asia, South East Asia
Elatostema paivaeanum Wedd.	Africa
Elatostema umbellatum (Siebold & Zucc.) Blume	East Asia
Elatostema papillosum Wedd.	South Asia, South East Asia
Elatostema strigosum Hassk.	South East Asia
Elatostema acuminatum (Poir.) Brongn.	South Asia, East Asia, South East Asia
Elatostema longipes W.T. Wang	East Asia
Elatostema involucratum Franch. & Sav.	East Asia
Elatostema parasiticum Blume ex H. Schroet.	South East Asia
Elatostema ficoides Wedd.	South Asia, East Asia, South East Asia
Elatostema parvum (Blume) Blume ex Miq.	South Asia, East Asia, South East Asia
Elatostema hookerianum Wedd.	South Asia, East Asia, South East Asia
Elatostema laevissimum W.T. Wang	East Asia, South East Asia
Elatostema macrophyllum Brongn.	South East Asia
Elatostema rupestre (Buch.-Ham. ex D. Don)Wedd.	South Asia, East Asia, South East Asia
Elatostema monandrum (Buch. -Ham. ex D. Don) H. Hara	South Asia, East Asia, South East Asia
Elatostema rostratum (Reinw. ex Blume) Hassk.	South Asia, South East Asia
Elatostema heyneanum (Wedd.) Hallier f.	South Asia, East Asia, South East Asia
Elatostema sp 1.	South East Asia
Elatostema sp 2.	South East Asia
Elatostema sp 3.	South East Asia
Elatostema sp 4.	South East Asia
Elatostema sp 5.	South Asia
Elatostema sp 6.	South East Asia
Elatostema sp 7.	South East Asia
Elatostema sp 8.	South East Asia
Elatostema sp 9.	South East Asia
Elatostema sp 10.	South East Asia
Elatostema sp 11.	South East Asia
Elatostema sp 12.	South East Asia
Elatostema sp 13.	South East Asia

Elatostema species used for food

In the current study we record a total of 16 *Elatostema* species used by various indigenous communities as food and vegetable (Table 2). In most of the cases leaves of *E. dissectum*, *E. sessile*, *E. lineolatum*, *E. platyphyllum*, *E. nasutum*, were boiled before consumption. Leaves of *E. laetevirens*, *E. lineolatum*, *E. acuminatum*, *E. macrophyllum* and *E. sp.*5 were cooked and used as a vegetable.

Shoots and leaves of *E. lineolatum* were boiled with rice to prepare "*Galho"***,** an *Angami* dish in Nagaland, India. *E. umbellatum* was recorded to be used as a side dish in our study. *E. involucratum* was cooked like a pot herb by *Hani* community in China. It was recorded that plant ash of *E. macrophyllum* was used as a salt substitute by *Samawa community* in Indonesia. Leaves of *E. sp.* 5 was cooked with meat or dry fish by the *Tangkhuls* of Manipur, India. 10 species in our studies were exclusively used as food (no medicinal, forage and other uses recorded).

Elatostema species as forage

Either the leaves or whole plants of **s**even species viz. *E. sessile*, *E. platyphyllum*, *E. cuneiforme*, *E. nasutum*, *E. hookerianum*, *E. laevissimum* and *E. sp.* 7 were recorded to be used by 11 Indian indigenous communities (*Nyishi*, *Monpa*, *Adi*, *Miji*, *Mao*, *Koki*, *Mizo*, *Galo*, *Apatani*, *Karbi*, *Limboo*) and *Ndumba tribe* of Papua New Guinea in our study. *E. sessile*, *E. platyphyllum*, *E. nasutum*, *E. hookerianum* and *E. laevissimum* were used as fodder to feed Mithun (*Bos frontalis*) in India, Nepal and China while leaves of *E. sp.*7 was used to feed pigs to increase their body fat by *Ndumba community* in Papua New Guinea (Table 2). In our study two species namely, *E. hookerianum* and *E. laevissimum* were recorded to be exclusively used as fodder by indigenous communities in China.

Elatostema species used for other purposes

In our study we recorded 10 *Elatostema* species used by six indigenous communities (*Nyishi*, *Melpa*, *Monpa*, *Samawa*, *Ndumba* and *Kalam*) for ornamental, material and magical purposes (Table 2).

E. sessile was found to be used as a frog poison by *Nyishis* (Arunachal Pradesh, India) (Srivastava & Nyishi, 2010); *E. beccarii* was recorded to be used for "counter magic" purposes by *Melpas* (Papua New Guinea) (Telban 1988). It is believed that if a person is possessed by a bush spirit demon or by a ghost, a healer uses leaves of *E. beccarii*, *Angiopteris sp.* and *Piper wichmannii* C. DC. which he ties up using a vine and then cooks them and rubs them over the skin of the possessed person to ward off the evil spirit (Telban 1988). Earth ovens are covered in the bottom by *E. beccarii* leaves and it is believed that this practice makes sure that their crops grow well, the men remain healthy and have a long life (Telban 1988).

E. cuneiforme and *E. nasutum* were used as rope or twine by *Monpas* (China). Plant ash of *E. macrophyllum* was used as a salt substitute by individuals of *Samawa community* (Sumbawa Island) *E. sp.* 6 and *E. sp.* 11 were used for ornamental and decoration purposes by *Ndumbas* and *Kalams* (Papua New Guinea).

Leaf area measurements

The usage of Wild leafy vegetables is decreasing around the world which has happened due to loss of knowledge systems needed for collection and preparation using wild plants and government development policies (Powell *et al.* 2014). In normal times no household depends entirely on wild edible plants for their nutrition throughout the year, but their collection and usage increase in unconventional times of food shortage and famine (Samant & Dhar 1997; Lescure *et al.* 1997). Leafy wild edible plants are crucial with a view of decreasing the lacuna in traditional knowledge and extracting the potential for their utilization (Konsam *et al.* 2016a). We were interested in knowing if the leaf area of the *Elatostema* species had any relation with its usage.

From our primary visual statistical leaf area analysis, we found that, leaf area for human consumption in both recorded and not recorded groups have highest data density within 0 to 50cm^2, not recorded group has higher data density than recorded group (Figure-2). Leaf area for medicinal use has similar kind of data density in both recorded and not recorded group, though not recorded group has highest data density between 1 to 50cm^2 and recorded group has data density around 50cm^2 (Figure-2). Data in recorded and not recorded group in case of forage seems quite differently distributed, highest data density in not recorded group is between 0 to 50cm^2, and in case of recorded group is around 50cm^2. In case of other use, the leaf area in recorded and not recorded group data density and distribution seems to vary quite highly, data density of not recorded group is highest between 0 to 50cm^2, and in recorded group 10 to 90cm^2 (Figure 2).

Data in Recorded and Not-recorded group for all the leaf use type ranges from 4.04 to 182.75cm^2, average leaf area in Recorded group for all the usage type ranges from 52.18 to 86.90cm^2 and in Not-recorded group ranges from 38.60 to 43.35cm^2, high data density in Recorded group ranges within 0 to 100cm^2, and in Not-recorded group ranges within 0 to 50cm^2 (Figure 3).

From Shapiro-Wilks test data in group Human consumption (p-value = 0.0005286), Medicinal use (p-value = 0.0005286), Forage (p-value = 0.0005286) and Other use (p-value = 0.0005286) were not found to be normally distributed (alpha = 0.05).

According to Kruskal-Wallis test (test for analysis of variance) there is no significant difference in data, between the groups. Human consumption, Medicinal use, Forage, Other use (df = 3, p-value = 1), and between the subgroups (Recorded and Not recorded) within groups viz. Human consumption (df = 1, p-value = 0.7158), medicinal purpose (df = 1, p-value = 0.09219), foraging (df = 1, p-value = 0.2433), other purpose (df = 1, p-value = 0.3653) (Figure 4).

When groups of leaf use (Human-consumption, Medicinal-use, Forage, Other-use) used as factors for performing PCA, component 1 and 2 explains about 59 % of variation in data and when subgroups within the main groups (Recorded, Not recorded) used as factors for performing PCA, component 1 and 2 explains 100 % of variation in data. There is a little data clustering observed but that is quite discrete and there is high overlapping of data clusters (Figure 5).

After performing all the analysis (density plots, Shapiro-Wilks test, Kruskal-Wallis test and Principal Component Analysis) we found out that there is no significant variation in leaf area with the type of use. We did not perform a regression analysis because for a meaningful regression analysis we need two numeric variables of equal variance in all groups (in our data set there is only one numeric variable, i.e., leaf area and number of observations for all groups in our data set is highly unequal). Detailed analysis of characters such as inflorescence size, plant height and abundance may provide some insights regarding species selection for type of use in *Elatostema* and related leafy wild plants of interest.

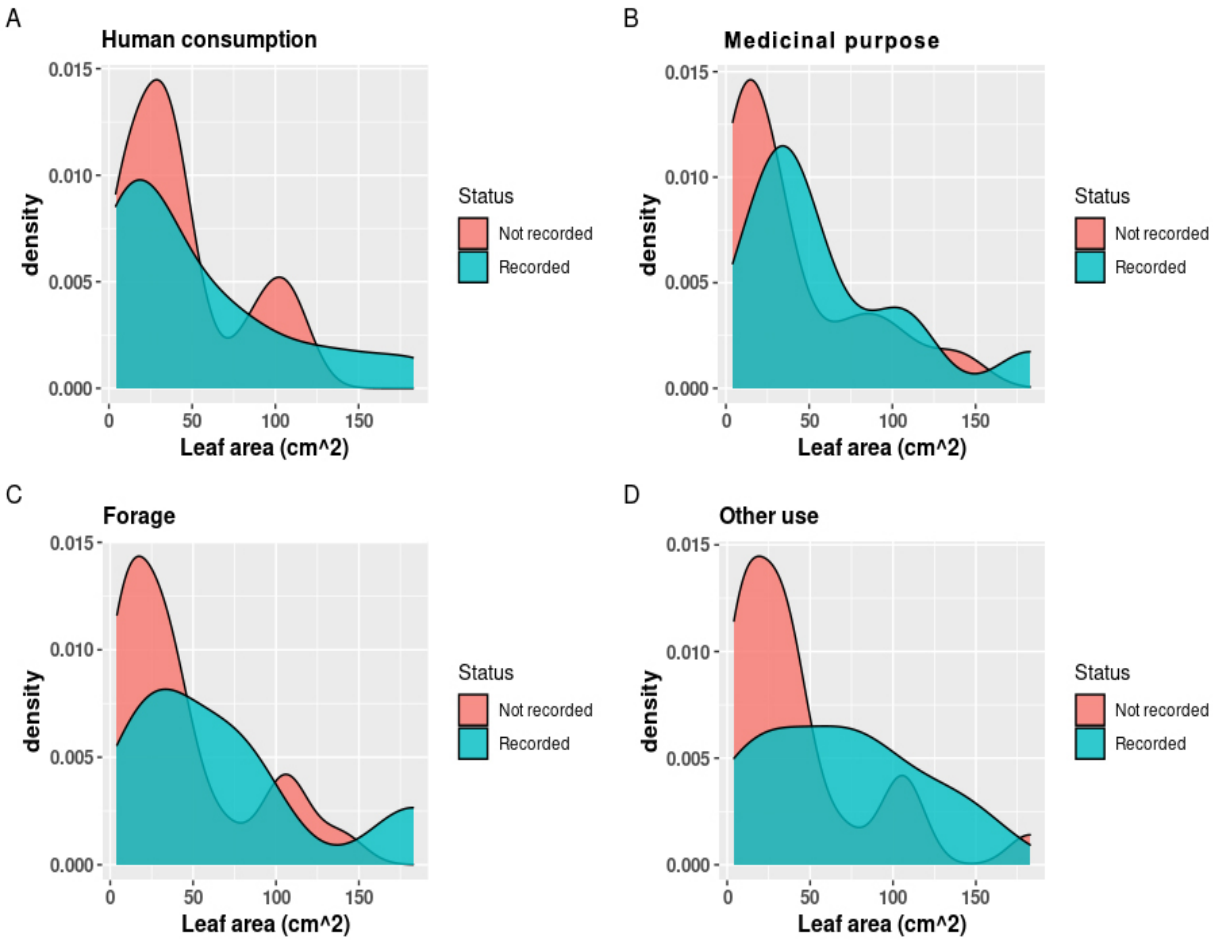

Figure 2. Density plot of leaf area regarding leaf use describing the data density in each group.

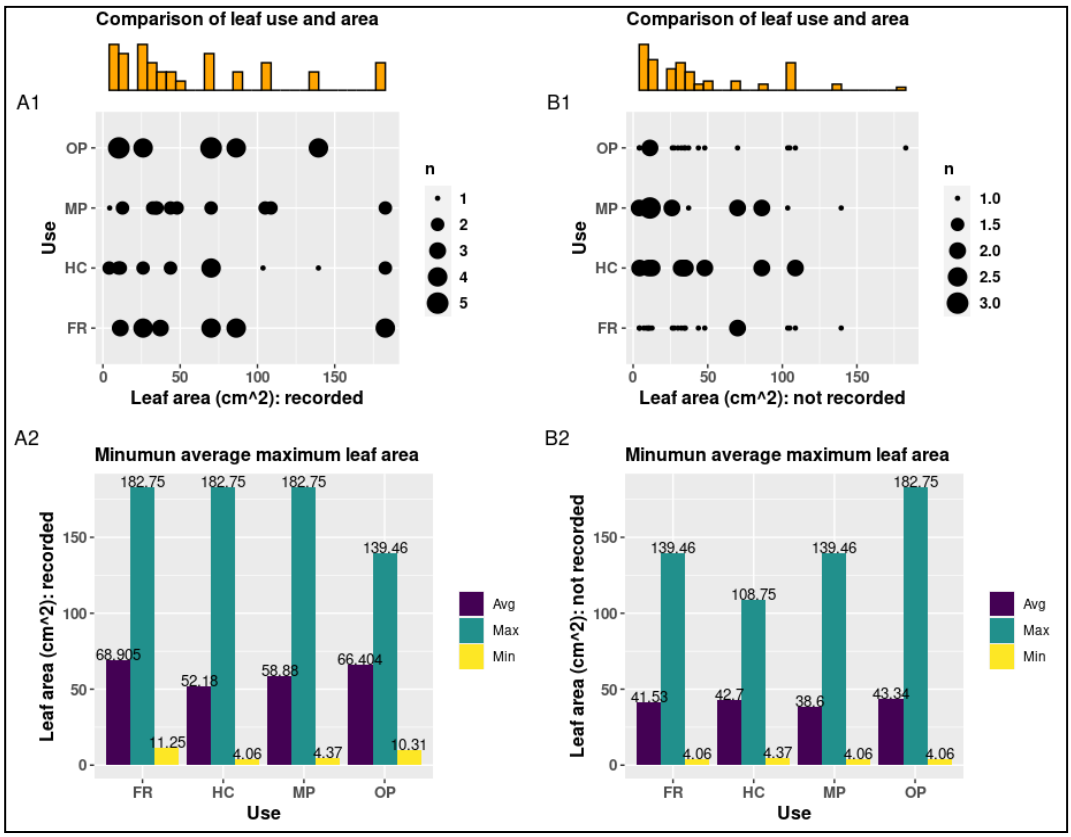

Figure 3. Visual analysis of parameters describing a comparative data density main and subgroups (A1, B1) and maximum, minimum, average leaf area in each main and subgroups (A2, B2) [FR = Forage, HC = Human consumption, MP = Medicinal use, OP = Other use].

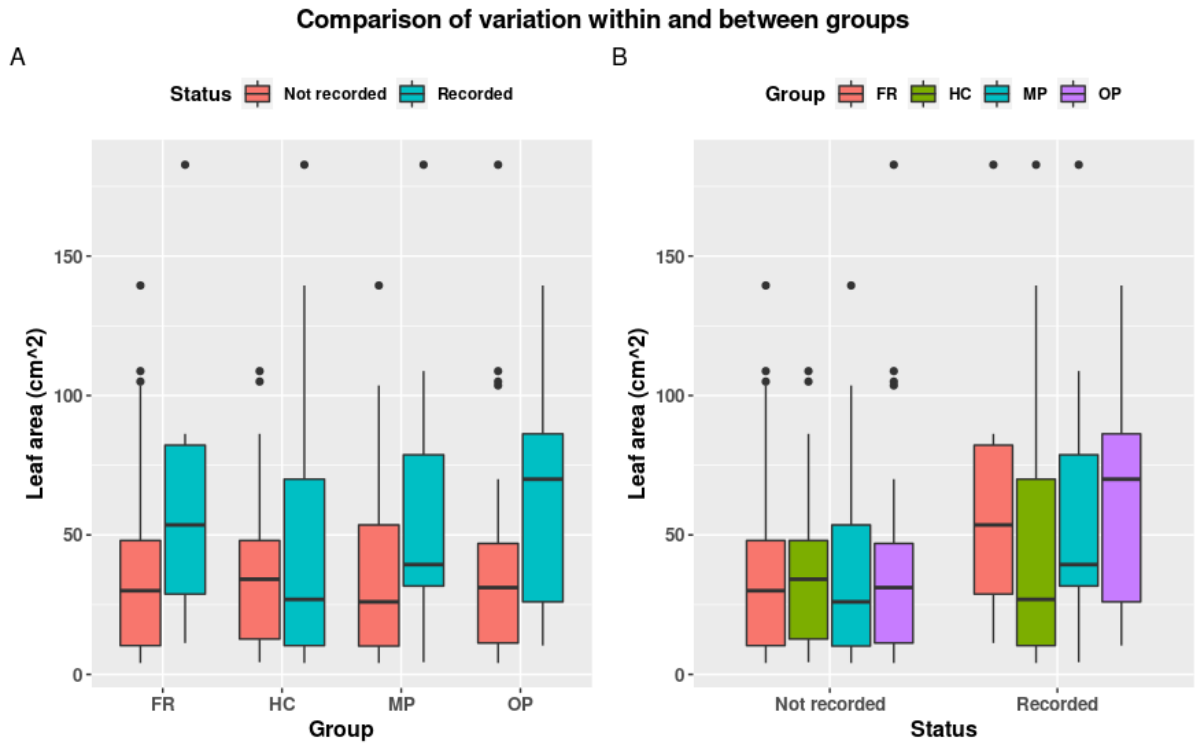

Figure 4. Boxplot showing variation in leaf area within and between groups

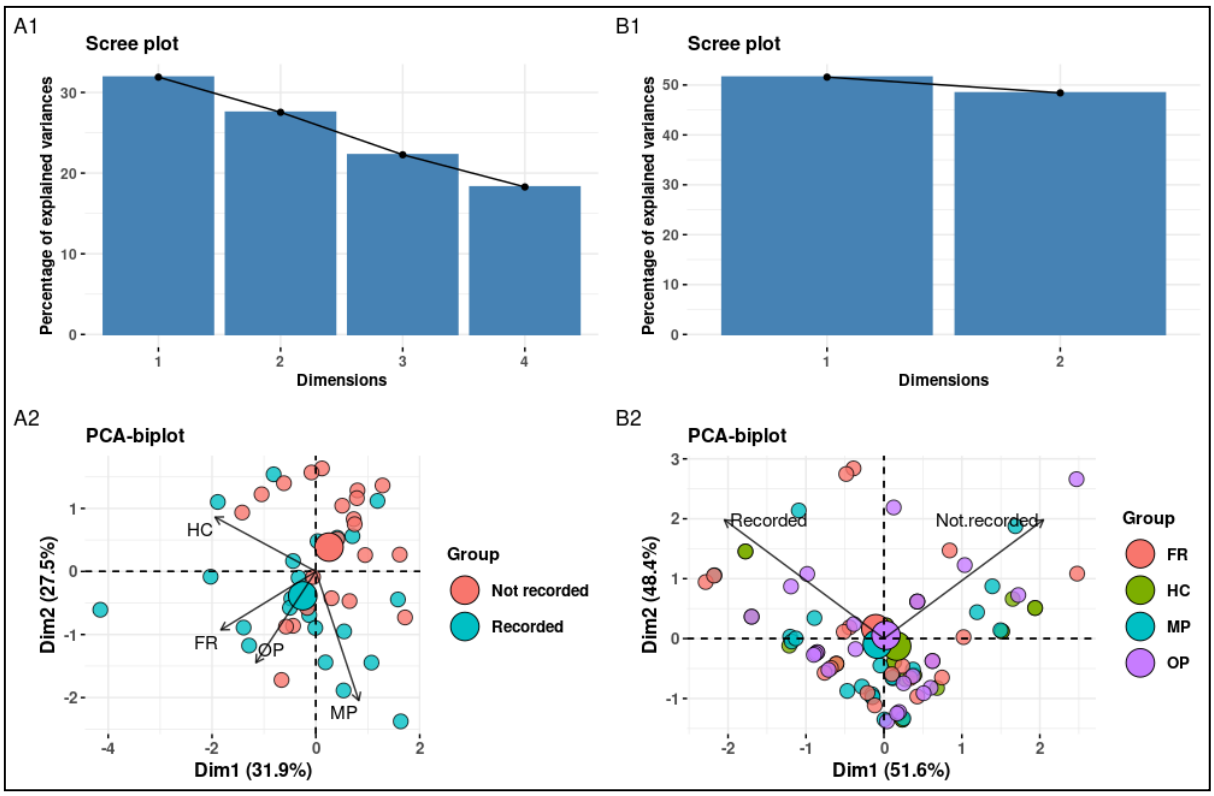

Figure 5. PCA biplot describing the data distributing and correlation between parameters [FR = Forage, HC = Human consumption, MP = Medicinal use, OP = Other use].

Use value

We recorded use values of 40 *Elatostema* species in our study. These values ranged from 0.18 to 1 (Appendix-2). In our study lower were the values, higher were the recorded usage and citations, for example, *E. platyphyllum* having UV 0.18 actually has the highest number of recorded usage and citation in our study and thus, a lower index, while on the other hand *E. rostratum, E. monandrum, E. sp1*, etc. having UV 1 actually have least number of recorded usage and citations in our study and higher index (Appendix-2).

Discussion

Loss of biodiversity is happening at an increasing rate across the globe especially in the forested areas near human habitations. The dependency of human beings on a few selected plant species and processed foods has also added to this destruction (Levin & Wilson 1976; Padro-De-Santayana *et al.* 2005; Goodman 2015). While agricultural societies depend mostly on few domesticated species, the indigenous people depend on wild plants for their nutrition (Konsam *et al.* 2016a). Since, they do not have large land holdings and are unable to afford basic agricultural equipment, they incorporate number of unconventional food plants in their diet (Samant & Dhar 1997; Padro-De-Santayana *et al.* 2005). Wild edible plants tend to be used as supplement or substitutes of food in times of dearth. Ethnobotanical studies play an important role in providing information about usage of wild plants and their morphology (Dogan *et al.* 2004). *Elatostema* is one such genus of interest with varied recorded usage by indigenous people in different parts of the world. Though leaf area does not show any relation to specific usage of species with in this genus, leaf size and morphology could be a target for selection of species in this genus for various ethnobotanical usage or even for their selection in bringing them for introduction to the mainstream food chain and also to develop proper agro-technological methods for cultivation. Moreover, variation in usage of *Elatostema* species shows its broad application.

Ethnobotanical analyses for species diversity and usage

Ethnobotanical studies provide a wide range of data on preparation methods, usage, medicinal values, toxicity and distribution of wild edible plants (Casas *et al.* 1996). It also shows how and why people selected specific plants for ethnobotanical usage and if there is a relation between the usage and availability of plants (Gaoue *et al.* 2017).

In our datasets we recorded 40 *Elatostema* species with ethnobotanical uses as food, medicinal, forage and others (material and ornamental). These uses were attributed to 30 indigenous communities across the world. Some 30 species recorded in our datasets were seen to have only a single usage, while 9 species were recorded to have two or more usage.

Among various indigenous communities, wild plants are an essential source of medicine to treat diseases and nearly 80-85% of population in emerging countries use conventional plants to treat various diseases and illness (Hamilton 2004; Dias *et al.* 2010; Ijaz *et al.* 2020).

The most frequent use of *Elatostema* species in our study is also as medicine followed by food, forage and material uses. Studies have shown that the antioxidant and cholinesterase inhibitory activities of *E. papillosum* leaves shows potential for treatment of Alzheimer's disease (Reza *et al.* 2018). We identified 20 *Elatostema* species (Table-2) used for medicinal purposes by various indigenous communities. Leaf was the most frequently used part for most of the medicinal preparations. Only in the cases of *E. integrifolium*, *E. platyphyllum* and *E. monandrum* the root juice was extracted and was used for treating fever, for inducing vomiting and for treating cuts and wounds respectively. Five species, *E. sessile*, *E. platyphyllum*, *E. papillosum*, *E. paivaeanum* and *E. strigosum* were used to treat gastrointestinal disorders and abdominal pain. Studies on plants to improve symptoms of Gastroesophageal reflux disease (GERD) conducted by Salehi *et al.* (2017) also shows that the antioxidant and anti-inflammatory properties of many wild plants helps in ameliorating the effects of gastrointestinal disorders. Furthermore, it also helps in increasing gastric mucous and decreasing gastric acids which helps in alleviating pain caused by stomach disorders (Salehi *et al.* 2017).

We recorded 16 species which are used for human consumption. Again, leaves were the most used plant part. *E. macrophyllum* was used as a salt substitute by the people of Samawa community (Indonesia) and indigenous communities of Papua New Guinea as in these areas the salt or salt water was difficult to procure therefore, leaf ashes of *E. macrophyllum* was used. This usage is attributed only to these communities as the availability of this species is recorded only from those areas (Rugayah *et al.* 1989).

Though we found uses of *Elatostema* from various countries, the depth of usage and documentation of usage was found to be more in India. We recorded 15 indigenous communities that use *Elatostema* for various purposes and of these communities, 14 were recorded to reside in North East India. This region is endowed with rich resources of land, water, forests and minerals and is inhabited by ca. 130 indigenous communities (Sengupta 2003). The usage of Wild edible plants in these areas were recorded to be higher than central part of India where the species diversity was low and very few indigenous communities remain (Samant & Dhar 1997). Even though the sources for collection of ethnobotanical data included literature survey from various areas and in different languages (Mandarin, Indonesian and Japanese etc.), there could be a disparity in the data due to the reason that we primarily used resources from Central National Herbarium (CAL) library and thereby, biasing the details of our study to India and to resources published in English language.

Use-value (UV) within the recorded species

Use-Value across recorded categories (Food, Medicinal, Forage and Others) and their citations showed that higher the usage and citations, lower the UV. So, in our case Use-values near 0 and under 1 had more recorded usage and citations while values over 1 had only one or two recorded usage and only one citation. *E. platyphyllum* (UV=0.18) and *E. sessile* (UV=0.23) have the maximum number of recorded usage and citations and thus have the lowest UV. These two species were also recorded to be used by maximum number of indigenous communities across the world. Species with UV>1 were seen to have only one or two recorded usage and citations. The reason for few recoded usage and citations could be associated to the restricted geographical range and endemism, as species such as *E. beccarii* H.Schroet., *E. paivaeanum* Wedd. and *E. strigosum* Hassk. were recorded to have very limited native range. The geographic distinctiveness could have resulted in limited usage by the indigenous communities residing in those areas. *E. beccarii* was used only by *Melpas* since this plant species is only found in Papua New Guinea (Telban 1988). Likewise, *E. paivaeanum* and *E. strigosum* were used only by *Chaggas* and *Batak Simalungans* respectively as these tribes reside in the native ranges from where these species have been identified and recorded.

Elatostema producing income for indigenous people

Wild plants have become a major source of income for indigenous communities (Salam *et al.* 2012; Muthu & Rimo 2018). These plants are sold in local markets at a very cheaper rate. Wild edible plants such as *Diplazium sp.*, *Piper pedicellatum* C. DC. and *Pilea sp.* were observed to be sold in the market along with *E. sessile* and *E. platyphyllum* in Arunachal Pradesh (Personal Observation). These plants are directly plucked or chopped off from their natural habitats and are sold for INR 20 ($0.27 USD) to INR 30 ($0.41 USD) for 500 grams in the local markets (Pfoze et al. 2012; Nyitan & Das 2018). The demand for these leafy vegetables especially *Pilea* and *Elatostema* species has increased in the local markets due to their availability all-round the year (Muthu & Rimo 2018). Konsam *et al.* (2016a) noted the high value of *E. lineolatum* along with other leafy vegetables used by ethnic communities of Manipur, India. This was attributed to the traits such as unique taste, edible parts, high abundance, ease of collection, processing and high market value of these plants.

Conclusion

This study illustrates diversity of *Elatostema* species used for human consumption, medicine, forage and ornamental or material purposes by various indigenous communities in the world. The study disproves our hypothesis that the usage of an *Elatostema* species for a specific purpose (human consumption, medicine, fodder, others) is related to leaf size, i.e., bigger the size of the leaves, more the chances of it to be used as food or forage. Results from our analyses shows that there is no variation in leaf area with the type of use. The documented ethnobotanical records of *Elatostema* species along with our personal observations in the field provided in this study would help in elucidating the importance of this genus as one of the main leafy wild edible plant for human consumption and will further

promote applied research in this group. *Elatostema* species can be further studied for their nutraceutical, anti-oxidant, medicinal and chemical properties and they can be brought under domestication and breeding in future. We further suggest comprehensive morphological and molecular studies of the related wild species with ethnobotanical uses for better identification of a promising candidate for domestication.

Declarations

List of abbreviations: WEP: Wild Edible plants, PCA: Principal Component Analysis, UV: Use-Value, NTFP: Non-Timber Forest Product, IPNI: International Plant Name Index

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Consent for publication: Not Applicable

Availability of data and material: The data was not deposited any public repositories.

Competing interests: The authors declare no competing interests.

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Authors' contributions: AKU was involved in data collection, literature survey and identification of plants. RG supervised the work and gave important inputs for the study. PKM was involved in conducting all the statistical analyses. All the authors (AKU, RG & PKM) contributed towards writing the manuscript.

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Appendices

Appendix 1. Leaf area of *Elatostema* species recorded in the study. Taxa identified up to the rank of species are taken for leaf area measurements, 13 taxa that are not identified up to the rank of species are not used for leaf area measurements.

Species	**Leaf area (cm^2)**
Elatostema dissectum Wedd.	$70cm^2$
Elatostema cuneatum Wight	$4.06cm^2$
Elatostema laetevirens Makino	$11.25cm^2$
Elatostema sessile J.R. Forst. & G. Forst.	$70cm^2$
Elatostema integrifolium (D. Don) Wedd.	$48cm^2$
Elatostema lineolatum Wight	$43.75cm^2$
Elatostema beccarii H. Schroet.	$10.31cm^2$
Elatostema platyphyllum Wedd.	$182.75cm^2$
Elatostema cuneiforme W.T. Wang	$86.25cm^2$
Elatostema nasutum Hook. f.	$26cm^2$
Elatostema paivaeanum Wedd.	$12.68cm^2$
Elatostema umbellatum (Siebold & Zucc.) Blume	$10cm^2$
Elatostema papillosum Wedd.	$34.12cm^2$
Elatostema strigosum Hassk.	$32.24cm^2$
Elatostema acuminatum (Poir.)B rongn.	$26.25cm^2$
Elatostema longipes W.T. Wang	$35cm^2$
Elatostema involucratum Franch. & Sav.	$8.8cm^2$
Elatostema parasiticum Blume ex H. Schroet.	$108.75cm^2$
Elatostema ficoides Wedd.	$105cm^2$
Elatostema parvum (Blume) Blume ex Miq.	$7.12cm^2$
Elatostema hookerianum Wedd.	$11.25cm^2$
Elatostema laevissimum W.T. Wang	$37.18cm^2$
Elatostema macrophyllum Brongn.	$139.46cm^2$
Elatostema rupestre (Buch.-Ham. ex D. Don) Wedd.	$27.5cm^2$
Elatostema monandrum (Buch.-Ham. ex D. Don) H.Hara	$4.37cm^2$
Elatostema rostratum (Reinw. ex Blume) Hassk.	$103.61cm^2$
Elatostema heyneanum (Wedd.) Hallier f.	$30cm^2$

Appendix 2. Use Value of *Elatostema* species recorded in the study

Species	**Use-Value**
Elatostema dissectum Wedd.	0.33
Elatostema cuneatum Wight	0.5
Elatostema laetevirens Makino	0.5
Elatostema sessile J.R. Forst. & G. Forst.	0.23
Elatostema integrifolium (D. Don) Wedd.	1
Elatostema lineolatum Wight	0.4
Elatostema beccarii H. Schroet.	1
Elatostema platyphyllum Wedd.	0.18
Elatostema cuneiforme W.T. Wang	2
Elatostema nasutum Hook. f.	1.5
Elatostema paivaeanum Wedd.	1
Elatostema umbellatum (Siebold & Zucc.) Blume	1
Elatostema papillosum Wedd.	1
Elatostema strigosum Hassk.	0.5
Elatostema acuminatum (Poir.) Brongn.	1
Elatostema longipes W.T. Wang	1
Elatostema involucratum Franch. & Sav.	1
Elatostema parasiticum Blume ex H. Schroet.	0.5
Elatostema ficoides Wedd.	1
Elatostema parvum (Blume) Blume ex Miq.	1
Elatostema hookerianum Wedd.	1
Elatostema laevissimum W.T. Wang	1
Elatostema macrophyllum Brongn.	0.66
Elatostema rupestre (Buch.-Ham. ex D. Don)Wedd.	1
Elatostema monandrum (Buch.-Ham. ex D. Don) H. Hara	1
Elatostema rostratum (Reinw. ex Blume) Hassk.	1
Elatostema heyneanum (Wedd.) Hallier f.	0.5
Elatostema sp 1.	1
Elatostema sp 2.	1
Elatostema sp 3.	1
Elatostema sp 4.	1
Elatostema sp 5.	1
Elatostema sp 6.	2
Elatostema sp 7.	3
Elatostema sp 8.	1
Elatostema sp 9.	1
Elatostema sp 10.	1
Elatostema sp 11.	1
Elatostema sp 12.	2
Elatostema sp 13.	1