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-Wilk's 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-Wilk's 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 Elatostematoideae C.B. Rob., Procris Comm. ex Juss. and Pellionia Gauchich. has been problematic since its inception (Hadiah et al. 2003; Hadijah & 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

| 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        | 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.

**H1**: There is a significant difference in leaf area regarding type of use.

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.
| 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*  | 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*    | Not Collected   | PAPUA NEW GUINEA        | Melpa tribe            | Kengana      | Leaves     | Not mentioned | Not mentioned | Not mentioned | Counter magic                      | Telban 1988                                                              |
| *Elatostema cuneatum*    | Not Collected   | INDIA                   | Monpa community        | Chulukpa     | Leaves     | Tender Leaves consumed as vegetable after proper leaching | Not mentioned | Not mentioned | Not mentioned                       |                                                                           |
| *Elatostema cuneiforme*  | Not Collected   | CHINA                   | Monpa community        | Tsen-tsen-pa | Stem       | Not mentioned | Not mentioned | Aerial parts used as forage          | Leaf juice is used for treating immunodeficiency in children and various liver diseases | Li et al. 2020 |
| *Elatostema dissectum*   | 71643           | INDIA(Meghalaya, Arunachal Pradesh) | Jaintia tribe          | Jhur Khiow  | Leaves, Fruits | Raw or Young Leaves cooked | Not mentioned | Not mentioned | Not mentioned                       |                                                                           |
| *Elatostema ficoides*    | Not Collected   | INDIA(Sikkim)           | Not mentioned          | Chiplu, Chiplay | Not mentioned | Ethnoveterinary medicine. 20-50gm plants crushed and given twice daily to lifestock to treat fever | Not mentioned | Not mentioned | Not mentioned                       | Bharti & Sharma 2012                                                      |
| *Elatostema heyneanum*   | Not Collected   | INDIA (Kerala)          | Cholanaikan tribe      | Elaven       | Leaves     | Leaf juice is used for treating immunodeficiency in children and various liver diseases | Not mentioned | Not mentioned | Not mentioned                       | Vilash et al. 2016; Kumar et al. 2019                                    |
| Species                                      | Code | Country/Region                          | Collection Status | Tribe/Community            | Part(s)            | Uses/Compounds                                                                 | citation                        |
|----------------------------------------------|------|----------------------------------------|-------------------|----------------------------|--------------------|-------------------------------------------------------------------------------|---------------------------------|
| *Elatostema hookerianum* Wedd.               | 71638| CHINA (Yunnan)                         | Not mentioned     | Kena, Shilikiangquing      | Whole plant        | Not mentioned                                                               | Not mentioned                   |
|                                              |      |                                        |                   |                            |                    | Used as fodder to feed Mithun (Bos frontalis)                                | Geng et al. 2017                |
| *Elatostema integrifolium* (D. Don) Wedd.    | 71647| NEPAL (N.Lipe Jhar)                    | Not mentioned     | Root                       | Not mentioned      | Juice of Root about 4 teaspoon is given 3 times a day in case of fever       | Not mentioned                   |
|                                              |      |                                        |                   |                            |                    |                                                                                | Manandhar 1993                  |
| *Elatostema involucratum* Franch. & Sav.     | Not  | CHINA                                  | Not Collected     | Hani tribe                 | Luo bu, Abo        | Tender stem, Leaf Potherb cooked like spinach                                | Not mentioned                   |
|                                              |      |                                        |                   |                            |                    |                                                                                | Lou et al. 2019                  |
| *Elatostema laetevirens* Makino              | Not  | CHINA, INDIA (Arunachal Pradesh)       | Not Collected     | Monpa community            | Leaves             | Tender Leaves cooked as vegetable                                            | Not mentioned                   |
|                                              |      |                                        |                   |                            |                    |                                                                                | Plants for a Future (https://pfaf.org/); Tsering et al. 2017                 |
| *Elatostema laevissimum* W.T. Wang           | Not  | CHINA (Yunnan)                         | Not Collected     | Not mentioned              | Whole plant        | Not mentioned                                                               | Not mentioned                   |
|                                              |      |                                        |                   |                            |                    | Used as fodder to feed Mithun (Bos frontalis)                                | Geng et al. 2017                |
| *Elatostema lineolatum* Wight                | 71641| INDIA (Arunachal Pradesh, Nagaland, Manipur, Assam, Nilgiris) | Monpa community | Dambe-hru, Angami tribe, Manipur, Ching sougri, Karbi-Anglong tribes | Shoots and leaves | Tender shoots and leaves used as vegetable; Boiled with rice to prepare Galho (Angami dish) | 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, Papua New Guinea | Samawa community | telat | stems, leaves | Eaten as vegetable; people eat plant ash as salt | Not mentioned | Not mentioned | Plant ash used as salt substitute | Rahayu & Rustiarni 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, isunguwa, lya muringm | 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 | Rahaman 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 | Huj | 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** | Tengup/Fangnap | Boiled before consumption | cuts caused by rocks; One tea cup of leaf decoction in water is taken for five days to treat dysentery | feed Mithun (Bos frontalis) |
|---|---|---|---|---|---|
| **Limboo tribe** | Gagleto | | | | |
| CHINA (Yunnan) | Zhemeng | | | | |
| NEPAL | Sano gangleto | | | | |

| 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 | Tatomung, Hopi-hojap | 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; |
| Species                        | Collection Location | Indigenous Name | Plant Part | Use | Disease | Other Uses |
|-------------------------------|---------------------|-----------------|------------|-----|---------|------------|
| *Elatostema strigosum* Hassk.  | Not Collected       | INDONESIA       | Sub-ethnic Batak Simalungun | Not mentioned | Used for treating hypertension, injury, gastrointestinal disorders and fever | Not mentioned |
|                               | (North Sumatra)     | Sisik naga      | Leaves, fruits | Not mentioned | | Not mentioned |
| *Elatostema umbellatum* (Siebold & Zucc.) Blume | Not Collected       | JAPAN (Irouzaki) | Uwabamiso | Not mentioned | Food, Used as side dish | Not mentioned |
|                               |                     |                 |            | | | Not mentioned |
| *Elatostema sp 1.*            | Not Collected       | INDONESIA       | Kaili Inde tribe | Not mentioned | Skin disease | Not mentioned |
|                               | (Central Sulawesi)  | Pedura walehu   |            | | | Not mentioned |
|                               |                     |                 |            | | | Not mentioned |
| *Elatostema sp 2.*            | Not Collected       | PAPUA NEW GUINEA (East Sepik Province) | Not mentioned | Kaskas-Bhirs | Scabies | Not mentioned |
|                               |                     |                 |            | | | Not mentioned |
| *Elatostema sp 3.*            | Not Collected       | PAPUA NEW GUINEA (East Sepik Province) | Not mentioned | Moin Kukuri | Fever, Headache, Joint Pain, Fertility | Not mentioned |
|                               |                     |                 |            | | | Not mentioned |
| *Elatostema sp 4.*            | Not Collected       | SUMATRA (Samosir district) | Not mentioned | Aup-Aup | Medicinal | Not mentioned |
|                               |                     |                 |            | | | Not mentioned |
| *Elatostema sp 5.*            | Not Collected       | INDIA (Manipur-Ukhrul district) | Not mentioned | Tangkhul tribe | Cooked with meat or dry fish | Not mentioned |
|                               |                     |                 |            | | | Not mentioned |
| *Elatostema sp 6.*            | Not Collected       | Papua New Guinea | Ndumba Tribe | Leaves | Leaves eaten as medicine | Leaves used as |
|                               |                     |                 |            | | | Hays 1980 |
| Elatostema sp 7. | Not Collected | Papua New Guinea | Ndumba Tribe | Nronggaaria ara | Leaves | Not mentioned | Leaves eaten as medicine | Leaves fed to pigs to increase their body fat | Ornamentation by women | Hays 1980 |
|-----------------|---------------|-------------------|--------------|-----------------|--------|---------------|--------------------------|----------------------------------|----------------------|-----------|
| Elatostema sp 8. | Not Collected | INDONESIA (Sumatra) | Not mentioned | Kerih | Leaves | Not mentioned | Leaves used in fever | Not mentioned | 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 | 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 | 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 | 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 | Not mentioned | 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)
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.

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 integrifoium* (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 rupestrae* (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 seven 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, Mji, 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, Melpas, 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*. 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 50cm², 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 50cm² and recorded group has data density around 50cm² (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 50cm², and in case of recorded group is around 50cm². 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 50cm², and in recorded group 10 to 90cm² (Figure 2).

Data in Recorded and Not-recorded group for all the leaf use type ranges from 4.04 to 182.75cm², average leaf area in Recorded group for all the usage type ranges from 52.18 to 86.90cm² and in Not-recorded group ranges from 38.60 to 43.35cm², high data density in Recorded group ranges within 0 to 100cm², and in Not-recorded group ranges within 0 to 50cm² (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.
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 ethno-botanical 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; ljaz 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. In Manipur, leaves were used for treating diarrhea and were 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 ethnomedical 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 recorded 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; Nyltan & 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 ethnomedicinal 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

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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 (cm²) |
|----------------------------------------------|-----------------|
| *Elatostema dissectum* Wedd.                 | 70cm²           |
| *Elatostema cuneatum* Wight                  | 4.06cm²         |
| *Elatostema laetevirens* Makino              | 11.25cm²        |
| *Elatostema sessile* J.R. Forst. & G. Forst. | 70cm²           |
| *Elatostema integrifolium* (D. Don) Wedd.    | 48cm²           |
| *Elatostema lineolatum* Wight                | 43.75cm²        |
| *Elatostema beccarii* H. Schroet.            | 10.31cm²        |
| *Elatostema platyphyllum* Wedd.              | 182.75cm²       |
| *Elatostema cuneiforme* W.T. Wang            | 86.25cm²        |
| *Elatostema nasutum* Hook. f.                | 26cm²           |
| *Elatostema paivaeanum* Wedd.                | 12.68cm²        |
| *Elatostema umbellatum* (Siebold & Zucc.) Blume | 10cm²       |
| *Elatostema papillosum* Wedd.                | 34.12cm²        |
| *Elatostema strigosum* Hassk.                | 32.24cm²        |
| *Elatostema acuminatum* (Poir.) Brongn.      | 26.25cm²        |
| *Elatostema longipes* W.T. Wang              | 35cm²           |
| *Elatostema involucratum* Franch. & Sav.     | 8.8cm²          |
| *Elatostema parasiticum* Blume ex H. Schroet.| 108.75cm²      |
| *Elatostema ficoides* Wedd.                  | 105cm²          |
| *Elatostema parvum* (Blume) Blume ex Miq.   | 7.12cm²         |
| *Elatostema hookerianum* Wedd.               | 11.25cm²        |
| *Elatostema laevissimum* W.T. Wang           | 37.18cm²        |
| *Elatostema macrophyllum* Brongn.            | 139.46cm²       |
| *Elatostema rupestre* (Buch.-Ham. ex D. Don) Wedd. | 27.5cm²    |
| *Elatostema monandrum* (Buch.-Ham. ex D. Don) H.Hara | 4.37cm²    |
| *Elatostema rostratum* (Reinw. ex Blume) Hassk. | 103.61cm²   |
| *Elatostema heyneanum* (Wedd.) Hallier f.    | 30cm²           |
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 papilosum* 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         |