FLORAL DIVERSITY OF INTEK RIVER IN TUBA, BENGUET, NORTHERN PHILIPPINES

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Abstract: Experts highlighted the importance of documenting the floral diversity of riparian zone ecosystems as these are among the current data gap to better identify global biodiversity threats, and address them by informed decision-making. Also locally, the river ecosystems in the Philippines are under-studied. To contribute to this, the study documented the vascular plants of Intek River in Tuba, Benguet using plot method. Intek River harbors a total of 146 species of vascular plants belonging to 130 genera and 59 families. Of these, 14 species are ferns, 37 species are monocot while the rest (95 species) are dicot. Majority of these species are indigenous (74) and endemic (24), with some exotic (25), weed species (21) and naturalized (2). The river also harbors five threatened, four vulnerable and one endangered species. Family Poaceae is the most represented with 17 species followed by Asteraceae with 9; Moraceae and Urticaceae with 8 each; and, Araceae with 7. In terms of biodiversity indices, the river registered high values in Shannon-Wiener index of 3.92, evenness of 0.56, Simpson’s index of 0.95 and Margalef’s index of 20.63. These high biodiversity indices and the high species richness of indigenous and endemic species in the river’s riparian zone could be attributed to the lesser degree of human disturbance in the area. These results of the study are important baseline information that could serve as indicator of ecosystem status; as baseline for impact assessment of any project implemented in that area; and, as baseline data for biodiversity conservation.

Keywords: biodiversity indices, endemic, indigenous species, Intek River, riparian zone ecosystem

Introduction:

The riparian zone ecosystems are among the world’s most diverse and dynamic floral habitats (Capon and Dowe 2012). These were described as the transitional areas between land and water, including the margins of streams, rivers, lakes, and wetlands. These riparian habitats are also regarded as biodiversity corridors because of the

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encompassing diverse collection of valuable species therein (Corbacho et al. 2003; Leibowitz 2003). A healthy riparian ecosystem is often indicated by its diverse floral species (Bhat et al. 2016). In addition, riparian zone ecosystems harbor aquatic macrophytes that are ecologically important. Aquatic macrophytes are large aquatic plants that comprise mosses, liverworts, larger algae as well as vascular plants (Aguilar 1997). They play an important role in structuring communities in aquatic environments by providing physical structure, increasing habitat complexity and heterogeneity and affecting various organisms like invertebrates, fishes and waterbirds (Thomaz and da Cunha 2010). Owing to their high rate of biomass production, macrophytes are important food resource for aquatic organisms, providing both living (grazing food webs) and dead organic matter (detritivorous food webs). The importance of both riparian zone ecosystem and of aquatic macrophytes therein highlights the need for their thorough inventory particularly in understudied sites.

The floral diversity is essential to the ecosystem's processes and functioning, particularly in protecting watersheds and stream ecosystem health (Naeem et al. 2001). It mitigates erosion, moderates climate, and provides shelter for animals. Due to these, floral diversity is a prerequisite for much fundamental research in community ecology, such as modelling patterns of species diversity or understanding species distribution (Phillips et al. 2003). Assessing the status and trends of floral diversity is also essential for sustainable development strategies at all levels, from village to nation to region (IUCN 2000). However, these considerations are seemingly still not appreciated in developing countries like the Philippines as reflected in the very limited inventory studies of riparian zone ecosystems (Langerberger 2004; Napaldet and Buot 2019; Baoanan et al. 2020). Amidst the mega-diverse and biodiversity hotspot status of the country, very few studies were conducted on the floral or macrophytes diversity in riparian zone ecosystems. These include the study of Aguilar and Buot (2003) and Vicencio and Buot (2017) on the aquatic macrophytes of Laguna de Bay; Torrefiel and Buot (2017) on the weed composition along Molawin Creek, Los Baños, Laguna; Napaldet and Buot (2017; 2019) on the aquatic macrophytes of Balili River, Benguet; and, Batani et al. (in press) on the floral diversity of Palina River, Benguet. These studies are very limited to adequately represent the presumed floral diversity of riparian ecosystems in the country brought about by the variation in terrain, elevation, climate and hydrologic conditions (Reyes – Boquiren 1995). This highlights the need for greater emphasis on floral diversity studies of understudied sites in the country like riparian zone ecosystems.

To contribute to the abovementioned data gap, this study has documented the floral diversity and species composition in Intek River of Tuba, Benguet, Northern Philippines. This floral assessment aims at providing basic information that could serve as indicator of ecosystem status, as baseline for impact assessment of any project implemented in that area, and as baseline data for biodiversity conservation. The basic premise for protection, preservation, and management of biodiversity and for preventing its further loss is to perform an inventory of the remaining flora (Phillips et al. 2003). Considering the rapid rate of biodiversity loss in the country, basic understanding and adequate accounting of the species diversity will be vital baseline information in crafting potential local, regional or national conservation methods (Bacudo et al. 2006).

Materials and methods:

Intek River, the Study Site

Intek River is a tributary of Asin-Gallano River that has its watershed headwaters originating from portions of Barangay Irisan, Quezon Hill and Pinsao Pilot in Baguio City and Barangay Puguis and Pico in the municipality of La Trinidad, Benguet. It is a mountain stream characterized primarily by riffles with three small waterfalls and some shallow pools. The river is an important irrigation source of the local community of Tadiangan, Tuba and the source of water for the operation of a micro hydro-electric plant in the area. Likewise, the river lies within the Marcos Highway Watershed Forest Reserve, a protected area under the Department of Environment and Natural Resources – Cordillera Central Range (DENR-CAR 2017). These considerations make its floral diversity assessment an important baseline information for planning and monitoring.

Floral Diversity Assessment Method

Three stations were established along Intek River namely upstream, midstream and downstream stations (Fig. 1). In each station, both opposing riparian zones were sampled. Thus, each station has two nested plots established – one each in the opposite riparian zones. A total of six nested plots were identified in the study.

Plot method was employed in data gathering of the study. This method is simple to use and the materials needed are readily available. Aside from its convenience, the uniform shapes of the plots together with the randomized distribution throughout the sampling area makes it straight forward. Although physically demanding, this method is not destructive (Napaldet and Buot 2019). Each nested plot consists of one (1) 20x50 m plot for trees, five 5x5 m plot for shrubs and 10 1x1 m quadrats for low-lying riparian herbs and grasses. Tree seedlings were considered in the understory herb inventory while climbing lianas, tall grass and woody plants with less than 5 cm dbh were considered in shrubs; and, woody plants that are 3 m tall or more and with greater than 5 cm dbh were considered as trees. This means that certain species that are counted as trees could also be counted under herb plot (as seedling) or under shrub plot (as sapling).

Plants within the plots were taxonomically identified. Several taxonomic references were used to verify the plants such as the published works of Pancho (1983), Rojo (1999) and Pancho and Gruezo (2006; 2009). On-line databases generated by Pelser et al. (2011 onwards) and that of tropicos.org (2013) were also consulted. Scientific names and classification were checked and verified in the Kew website: http://www.plantsoftheworldonline.org/.

Density, frequency, coverage (for shrubs) and basal area (for trees) were the primary parameters used to determine the importance value of the plants. These were computed as follows:

Density (Di)

$$\mathrm{D}i = \frac{\mathrm{n}i}{\mathrm{m}^2}$$

where:
ni = number of individual of speies i;
m = total area sampled

Frequency (Fi)

$$\mathrm{F}i = \frac{\mathrm{J}i}{\mathrm{K}} \mathrm{x}\ 100$$

where:
Ji = number of plot where the species occur;
K = total number of plots

Coverage (Ci) (for shrubs only)

$$\mathrm{C}i = \frac{\left(\pi\left(\frac{CRL}{2}\right)^2\right) + \left(\pi\left(\frac{CRW}{2}\right)^2\right)}{2}$$

where:
CRL = lenght of crown;
CRW = width of crown

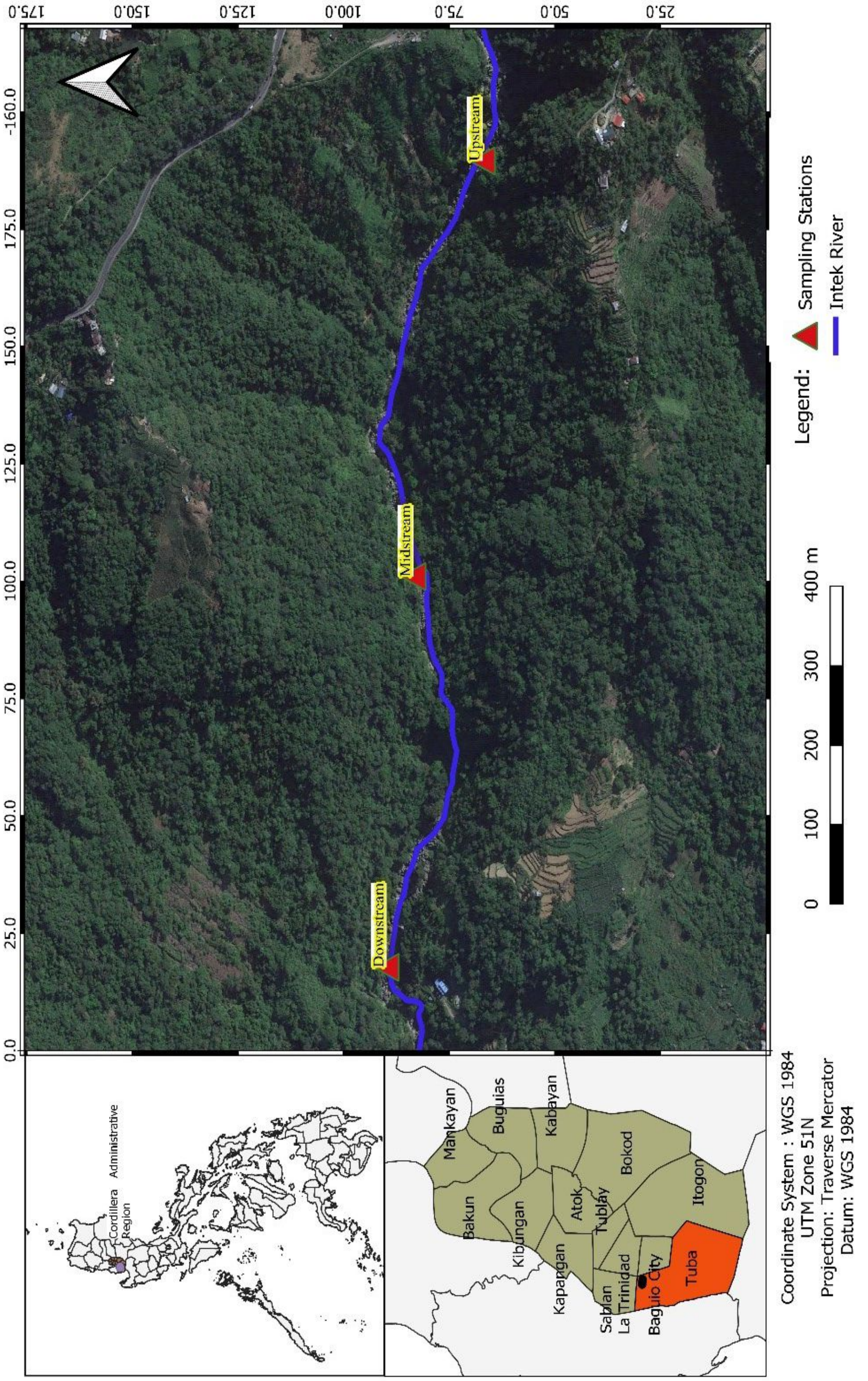


Figure no. 1 The sampling stations in Intek River, Tuba, Benguet

Basal Area (TBA*i*) (for tree only), measured in metres squared (m^2)

$$\text{TBA}i = \pi \text{ x } \left(\frac{\text{DBH}i}{200}\right)^2$$

where
DBH = diameter at breast height, measured in centimetres

Relative Density (RD*i*)

$$\text{RD}i = \frac{\text{D}i}{\text{TD}} \text{ x } 100$$

where:
D*i* = density of species *i*;
TD = total density of all species

Relative Frequency (FR*i*)

$$\text{RF}i = \frac{\text{F}i}{\text{TF}} \text{ x } 100$$

where:
F*i* = frequency of species *i*;
TF = total frequency of all species

Relative Coverage (RC*i*)

$$\text{RC}i = \frac{\text{C}i}{\text{TC}} \text{ x } 100$$

where:
C*i* = coverage of species *i*;
TC = total coverage of all species

Relative Basal Area (RBA*i*)

$$\text{RBA}i = \frac{\text{BA}i}{\text{TBA}} \text{ x } 100$$

where:
BA*i* = Basal Area of species *i*;
TBA = Total Basal Area of all species

Importance Value for herbs (IV*hi*)

$$\text{IV}hi = \frac{\text{RD}i + \text{RF}i}{2}$$

where:
RD*i* = Relative Density of species *i*
RF*i* = Relative Frequency of species *i*

Importance Value for shrubs (IV*shi*)

$$\text{IV}shi = \frac{\text{RD}i + \text{RF}i + \text{RC}i}{3}$$

where:
RD*i* = Relative Density of species *i*
RF*i* = Relative Frequency of species *i*
RC*i* = Relative Coverage of species *i*

Importance Value for tree (IV*tri*)

$$\text{IV}tri = \frac{\text{RD}i + \text{RF}i + \text{RBA}i}{3}$$

where:
RD*i* = Relative Density of species *i*
RF*i* = Relative Frequency of species *i*
RBA*i* = Relative Basal Area of species *i*

Biodiversity Indices

Additionally, diversity indices such as Shannon, Simpsons, Margalef and Jaccard index of similarity were computed. Shannon-Wiener diversity index takes into account species richness and the proportion of each species within the local community. It also takes into account evenness or the distribution of individuals among the species. It was calculated as follows:

$$\text{H} = \sum_{i=l}^{S} pi(lnpi)$$

where:
H = Shannon-Wiener diversity index
pi = number of individuals of species *i*/ total number of samples
S = number of species or species richness

Evenness quantitatively depicts the distribution of species within the area. It is interpreted as 0 with no evenness or complete dominance and 1 with complete evenness or equal distribution. It was calculated as follows:

$$E = \frac{H}{Hmax}$$

where:

E = evenness

H_{max} (maximum diversity possible) = ln (N)

Simpson's diversity index is the complimentary of evenness. It is the common measure of dominance with values ranging from 0 to 1 – 1 represents infinite diversity and 0, no diversity (Barcelona Field Studies Centre 2018). It was computed as follows:

$$D = 1 - \sum_{i=1}^{s} \frac{ni(ni-1)}{N\,(N-1)}$$

where:

D = Simpson's diversity index

n*i* = total individual of species *i*

N = total number of individual of all species

On the other hand, Margalef's index is simpler. It was computed as:

$$R = \frac{(S-1)}{\ln(N)}$$

where:

R = richness

S = # of species

N = # of individuals (of all species)

To compare the diversity among sampling stations, Jaccard index of similarity was used. It was computed as:

$$J = \frac{Sc}{Sa + Sb + Sc}\, x\, 100$$

where:

J = Jaccard index of similarity

Sc - number of species common to the two samples

Sa - number of species unique to station a

Sb - number of species unique to station b

Results and discussion:

A total of 146 species belonging to 130 genus and 59 families was inventoried in Intek River (Fig. 2). Of these, 14 species are ferns, 37 species are monocot while the rest (95 species) are dicot. Majority of these species are indigenous (74) and endemic (24), with some exotic (25) and weed species (21) (Fig. 3). Much of the exotic and weed species are herbs that grow on exposed soils in the riparian as it subsides during summer months. Most likely, the seeds of these plants are deposited by waterflow from the upstream and would eventually be uprooted when the river flow turns violent during rainy season. On the other hand, the indigenous and endemic species in the river stations were located above the riparian and are critical in holding on the soil and preventing erosion of the riverbank, particularly that the slope along the river is very steep (65-90°). These species also were characteristics of a secondary and riverine forest in the country. Majority are of least concern status, thus not much of conservation importance. Nonetheless, there are few conservation important species wherein 5 are threatened, 4 are vulnerable and 1 endangered species (Tab. 1).

The species richness of Intek River is much higher than floral diversity of the nearby Balili River which recorded only 9 total species by Napaldet and Buot in 2017 and 37 species by the same author in 2019. The significant difference could be directly attributed to dominant human disturbance experience by Balili River compared to the lesser human disturbance in Intek River. Our result is more comparable with the floral diversity of Palina River by Batani et al. (in press) wherein a total 92 species of riparian vascular plants belonging to 84 genera under

42 families were documented. Palina River has the same general physical feature as that of Intek River but is located in a different municipality – in Kibungan.

The high species richness of indigenous and endemic species in Intek River is encouraging. Their prevalence on the site most likely control the spread of exotic and weed species. This is in direct contrast with the case of the documented disturbed sites in the locality. For example, Antonio et al. (2020) reported that 60% of all vascular plants in Benguet State University La Trinidad Campus – an intensively human-managed area – are exotic species. This is also consistent with Guron et al. (2019) which found exotic floral species to be predominant in highly disturbed agricultural plots of Talingguroy Research Station, La Trinidad. These observations are making it clear that the degree of human disturbance is directly correlated with the diversity of indigenous, endemic and exotic floral species in the region. Exotic floral species are common in highly disturbed sites while indigenous and exotic species are minimized. This is opposite in less disturbed sites which harbour several indigenous and exotic species while exotic species are controlled.

Figure no. 2 The floral species richness and composition of Intek River of Tuba, Benguet, Northern Philippines

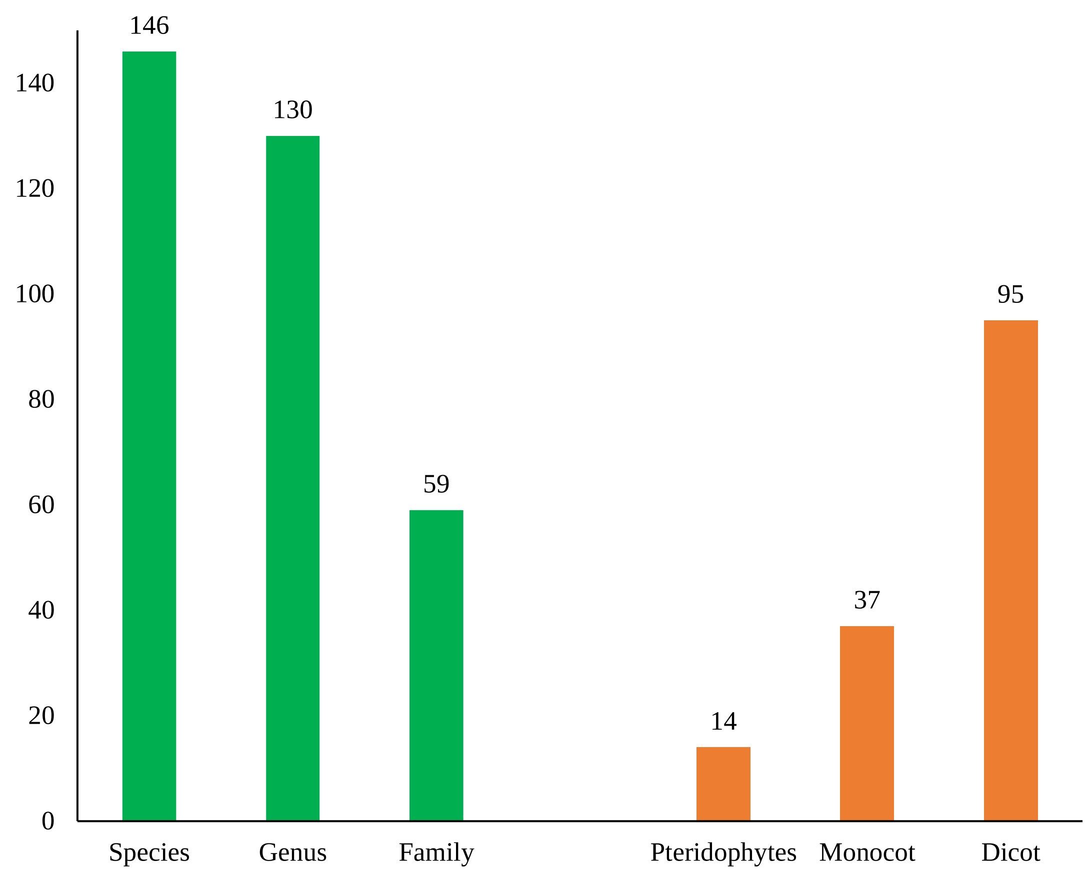


Figure no. 3 The ecological distribution and conservation status of plant diversity in of Intek River of Tuba, Benguet, Northern Philippines

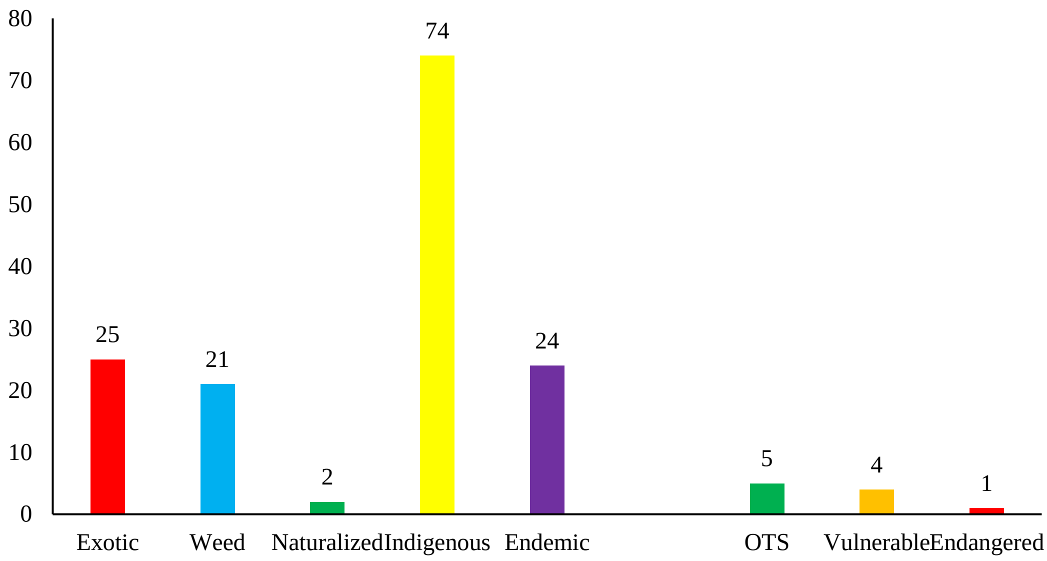


Table no. 1 List of the conservation-important plant species along Intek River

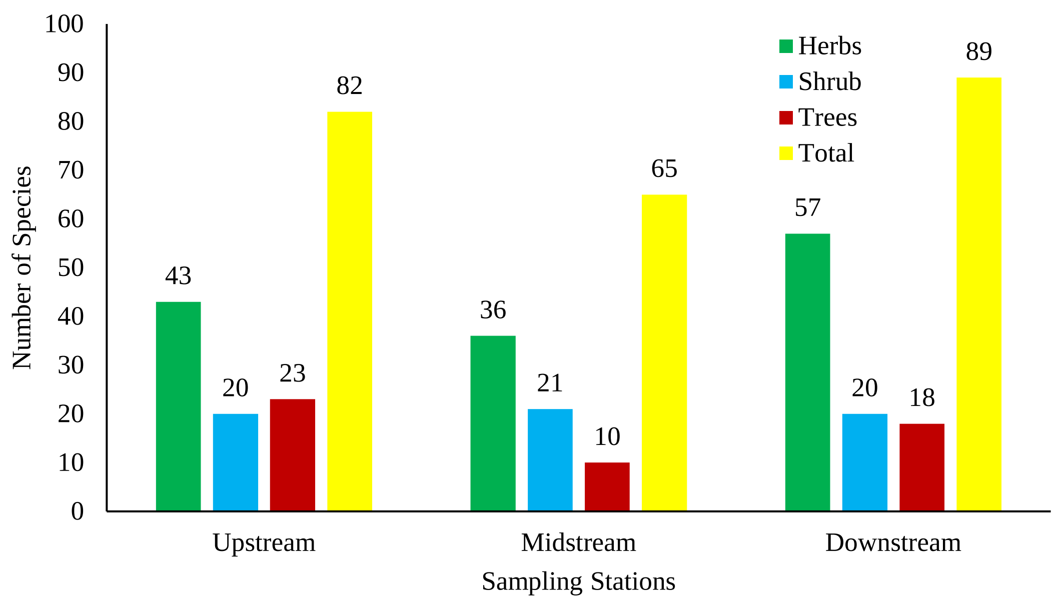
Scientific name	Family	Common / Local name	Conservation Status*	Station where it occur
Aglaia cumingiana	Meliaceae	Alauihau	OTS	All stations
Angiopteris palmiformis	Marattiaceae	giant fern	OTS	Midstream
Cinnamomum mercadoi	Lauraceae	kalingag	OTS	Upstream
Dinochloa acutiflora	Poaceae	climbing bamboo	OTS	All stations
Vanoverberghia sepulchrei	Zingiberaceae	‘Akbab’	OTS	Upstream and midstream
Alocasia micholitziana	Araceae	Velvet gabi	Vulnerable	Upstream and midstream
Balakata luzonica	Euphorbiaceae	Balakat-gubat	Vulnerable	Upstream
Bulbophyllum curranii	Orchidaceae	graceful bulbophyllum	Vulnerable	Upstream and downstream
Pterocarpus indicus	Fabaceae	Narra	Vulnerable	All stations
Cyathea contaminans	Cyatheaceae	Tree fern	Endangered	Midstream and downstream

Note: OTS – other threatened species; names in apostrophe are vernacular names; * - conservation status is based on DENR-Administrative Order 2017-11

In particular, the dominance of *Dinochloa acutiflora* has greatly limited the occurrence of the exotic and weed species in the river stations. This climbing bamboo is very dominant, particularly along the west northern riparian zone, that it forms a continuous mat from the upstream to downstream and prevent much of the undergrowth. This also stabilizes the bank against erosion.

Between stations, the Downstream stations has the highest species richness of 89 followed by Upstream Station with 82 and least in Midstream Station with 65 (Fig. 4). It can be readily gleaned from the figure that understory species such as herbs/grasses and shrubs highly outnumbered the tree species. This result is consistent with other forest site inventories in Cordillera Central Range by Guron et al. (2019), Guron et al. (in press), Batani et al. (in press) and Alafag et al. (in press) wherein understory species highly outnumber the tree species. This strongly supports the claim of Langerberger (2004) that understory plants should also be prioritized together with tree species in forest inventories.

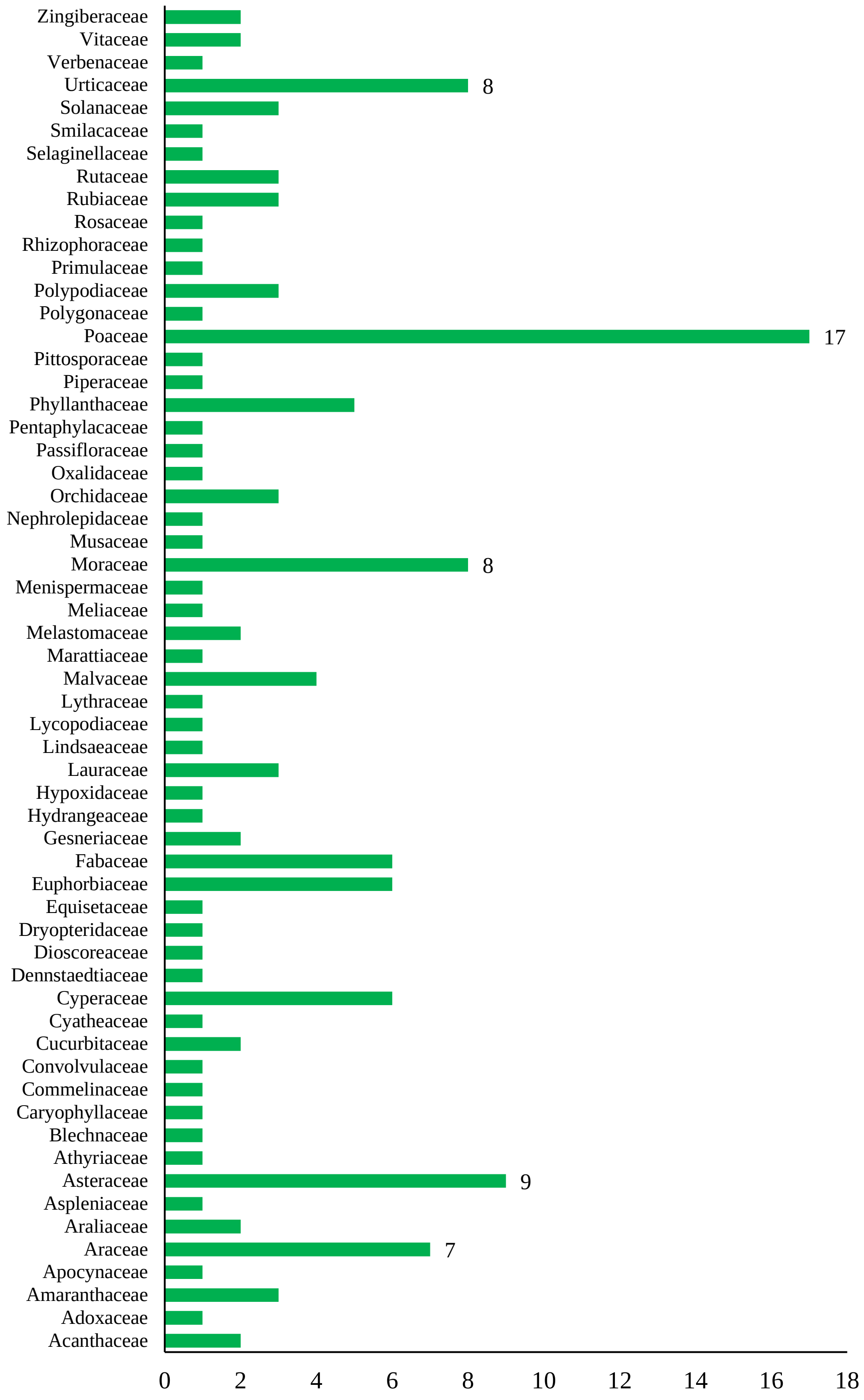
Figure no. 4 The species richness by sampling stations of Intek River of Tuba, Benguet, Northern Philippines



Family Poaceae is the most represented with 17 species followed by Asteraceae with 9; Moraceae and Urticaceae with 8; and, Araceae with 7 (Fig. 5). Majority of the Poaceae, and Asteraceae species were common weeds; Moraceae species were pioneer and riverine trees; while Urticaceae and Araceae species were predominantly native low-lying herbs. The rest of the other families were represented by one or two species.

The species richness of families Asteraceae and Poaceae in the river is not unexpected since these are two of the largest plant families (Pancho and Gruezo 2012). These families harbour species of certain importance and feature wide distribution. Asteraceae family or sunflower family consists of 1,911 genera and 32,205 species worldwide (Royal Botanic Gardens Kew and Missouri Botanic Garden (2019), while Poaceae has 759 genera and 11,554 species.

Figure no. 5 The species distribution by families in of Intek River of Tuba, Benguet, Northern Philippines



Several species under these families serve as crops, ornamentals and weeds contributing to their wide distribution. On the other hand, family Moraceae was largely represented by six *Ficus* spp. which are known to thrive in moist habitat and are important reforestation tree species as well as food sources for frugivores (Stier and Mildenstein 2005).

Dominant plant species

The dominant plant species in the sampling stations along Intek River are presented in Table 2 (Annexes). On the other hand, the detailed population counts were presented in Table 1 to 3. Among herbs and shrubs, the majority of the dominant species are indigenous species, particularly *Elatostema banahaense* for herbs and *Dinochloa acutiflora* for shrubs. In Upstream and Midstream Stations, *E. banahaense* and *Oplismenus hirtellus* are clearly dominant herbs as shown by their significantly higher importance values. However in Downstream Station, the importance values of the dominant herbs are not largely different. The predominance of indigenous species in the understory is attributed to the shaded and moist condition of the riparian zone. *Elatostema banahaense*, *Schismatoglottis merrillii* and *Selaginella plana* are known to be hydrophilic herbs. The exotic species *Ageratina riparia* was also relatively dominant in Upstream and Downstream stations but is not the most dominant. This is an encouraging report because elsewhere in the Cordillera Central Range, this species is becoming dominant understory particularly in disturbed sites. *Ageratina riparia*, a native of South America (Turner 1997), was found dominant by Batani et al. (in press) in Palina River, Kibungan and by Guron et al. (2019) in Talinguroy Research Station, La Trinidad.

The dominant understory species of Intek River is very different compared with the nearby Balili River in La Trinidad, Benguet. In Balili River, the dominant herbs were exotic species and weeds. As regards the two rivers, only *Pennisetum purpureum* and *Setaria palmifolia* were the similar dominant herbs. This observation directly contrasts a highly disturbed river (as the case of Balili River) with a less disturbed one (as was the case of Intek River) wherein exotic and weed species are dominant in former while indigenous and endemic species predominate in the latter.

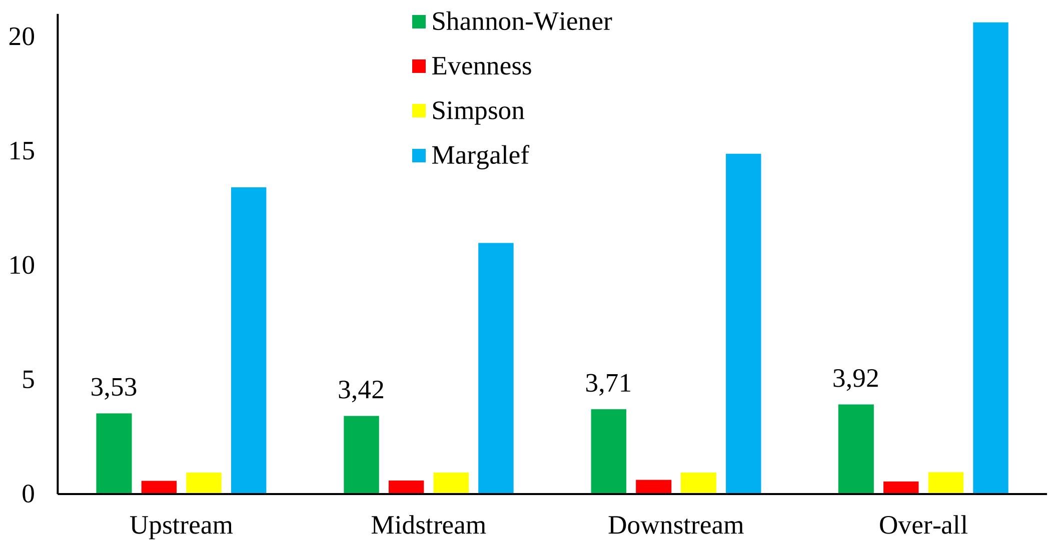
The dominance of *Dinochloa acutiflora*, particularly on the west northern riparian zone, also helps control the growth of exotic and weed herbs. Dominant trees, on the other hand, are characteristics of secondary and riverine forest. This include trees known to dominate in secondary forest at low to mid-elevation such as *Bischofia javanica*, *Litsea cordata* and *Commersonia bartramia*; and, hydrophilic trees like *Ficus* spp.

Biodiversity Indices

Figure 6 presents the biodiversity indices of the sampling stations along Intek River. In most ecological studies, Shannon-Wiener's index was generally between 1.5 and 3.5 with higher number indicating greater species richness and evenness (Fernando 1998). The upstream, midstream and downstream stations registered a relatively equal values of Shannon-Wiener's index at 3.42 – 3.71, which would be categorized as very high diversity. Overall, Intek River registered high floral diversity indices with Shannon-Wiener index of 3.92, evenness of 0.56, Simpson's index of 0.95 and Margalef's index of 20.63.

Our result is much higher than the biodiversity indices recorded by Napaldet and Buot (2019) in Balili River, La Trinidad with Shannon-Wiener's, evenness, Simpson's, Margalef's indices of 1.66, 0.249, 0.946 and 5.56, respectively. Also is comparable with the result of Batani et al. (in press) in Palina that recorded Shannon-Wiener's of 3.39, evenness of 0.60, Simpson's 0.94 and Margalef's index of 10.59 in Palina River and with the result of Guron et al. (2019) in Talinguroy Research Station and of Lumbres et al. (2014) in Alno Communal Forest. The environmental conditions in Intek River are not significantly impacted by human disturbance thus allowing the survival of locally-adapted endemic and indigenous species. From these, a direct comparison between an urban and rural river could be made and again the value of pristine rivers as hub for biodiversity was highlighted.

Figure no. 6 The diversity indices of the sampling stations in of Intek River of Tuba, Benguet, Northern Philippines



Lastly, Table 3 presents the Jaccard Index of Similarity between the sampling stations. It can readily gleaned from the table that the sampling stations differ significantly in terms of species composition as indicated by 18-20% similarity. This also contributes to high diversity indices of the river since the species composition are highly diverse among stations even if they are just few kilometers apart.

Table no. 3 Jaccard's index of similarity (%) among stations

	Upstream	Midstream
Midstream	19.67	
Downstream	20.83	18.95

Conclusions:

The study documented the vascular plants in Intek River as part of the on-going effort to properly account for the floral diversity in the Cordillera Central Range (CCR), particularly in non-prioritized areas like riparian zone ecosystem. Intek River harbours a total of 146 species of vascular plants belonging to 130 genera and 59 families, of which majority are indigenous (74) and endemic (24) with some exotic (25) and weed species (21). The river also harbors five threatened, four vulnerable and one endangered species. The river registered high floral diversity indices with Shannon-Wiener index of 3.92, evenness of 0.56, Simpson's index of 0.95 and Margalef's index of 20.63. The high species richness of indigenous and endemic species as well as the high biodiversity indices of Intek River could be directly attributed to the relatively less human disturbance in the area. This directly contrasts with the disturbed sites in the area that were documented by other studies like Balili River and agricultural sites that registered low species richness, low biodiversity indices and high number of exotic and weed species. With these results, the authors are confident to conclude that the degree of human disturbance is directly correlated with the diversity of indigenous, endemic and exotic floral species in the CCR. Exotic floral species are common in highly disturbed sites while indigenous and exotic species are displaced. This is opposite in less disturbed sites which harbour several indigenous and exotic species while exotic species are controlled.

Rezumat:

DIVERSITATEA FLORALĂ A RÂULUI INTEK ÎN TUBA, BENGUET, FILIPINE DE NORD

Lumea științifică a evidențiat importanța studierii diversității florale a ecosistemelor zonelor riverane, deoarece acestea se numără printre lacunele de date actuale pentru a identifica mai bine amenințările globale la adresa biodiversității și a le aborda printr-un proces decizional informat. De asemenea, la nivel local, ecosistemele fluviale din Filipine sunt puțin studiate. Pentru a contribui la aceasta, studiul s-a axat pe plantele vasculare ale râului Intek din Tuba, Benguet, folosind metoda graficului. Râul Intek adăpostește un total de 146 de specii de plante vasculare aparținând la 130 genuri și 59 familii. Dintre acestea, 14 specii sunt ferigi, 37 de specii sunt monocotiledonate, în timp ce restul (95 specii) sunt dicotiledonate. Majoritatea acestor specii sunt indigene (74) și endemice (24), o parte din ele sunt exotice (25), specii de buruieni (21) și naturalizate (2). Râul adăpostește și cinci specii amenințate, patru vulnerabile și una pe cale de dispariție. Familia Poaceae este cea mai bine reprezentată cu 17 specii, urmată de Asteraceae cu 9, Moraceae și Urticaceae cu câte 8, și Araceae cu 7. În ceea ce privește indicii biodiversității, râul a înregistrat valori ridicate la indicele Shannon-Wiener de 3.92, uniformitatea de 0.56, indicele Simpson de 0.95 și indicele Margalef de 20.63. Acești indici ridicați ai biodiversității și bogăția ridicată a speciilor indigene și endemice din zona riverană a râului ar putea fi atribuite gradului mai mic de perturbări umane din zonă. Aceste rezultate ale studiului sunt informații importante de bază care ar putea servi drept indicator al stării ecosistemului; ca bază pentru evaluarea impactului oricărui proiect implementat în acea zonă; și, ca date de bază pentru conservarea biodiversității.

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Annexes:

Table no. 2 The dominant herbs, shrubs and trees in the sampling stations along Intek River

Herbs	IV	Shrubs	IV	Trees	IV
Upstream Stations					
Herbs	IV	Shrubs	IV	Trees	IV
Elatostema banahaense	17.81	*Dinochloa acutiflora*	36.88	*Bischofia javanica*	11.30
Oplismenus hirtellus	11.78	*Acalypha amentacea*	12.75	*Commersonia bartramia*	11.25
Ageratina riparia	7.13	*Poikilospermum acuminatum*	6.56	*Litsea cordata*	9.41
Commelina diffusa	4.43	*Oreocnide trinervis*	5.05	*Litsea glutinosa*	9.09
Drymaria cordata	4.27	*Leea guineensis*	4.51	*Ficus minahassae*	8.53
Elephantopus tomentosus	4.27	*Miscanthus floridulus*	4.48	*Ficus benguetensis*	5.64
Desmodium incanum	4.16	*Vanoverberghia sepulchrei*	4.41	*Ficus linearifolia*	5.00
Cyrtococcum patens var. *latifolium*	3.91	*Litsea cordata*	3.69	*Aglaia cumingiana*	4.56
Equisetum ramosissimum	3.15	*Tithonia diversifolia*	3.09	*Ficus microcarpa*	4.42
Scindapsus curranii	2.70	*Pennisetum purpureum*	2.90	*Ficus nota*	3.51
Midstream Stations					
Herbs	IV	Shrubs	IV	Trees	IV
Elatostema banahaense	18.97	*Dinochloa acutiflora*	22.32	*Ficus nota*	22.01
Oplismenus hirtellus	11.14	*Angiopteris palmiformis*	17.64	*Bischofia javanica*	18.83
Selaginella plana	9.11	*Acalypha indica*	10.22	*Ficus minahassae*	16.68
Schismatoglottis merrillii	6.69	*Leea guineensis*	8.18	*Commersonia bartramia*	10.85
Mikania cordata	5.09	*Vanoverberghia sepulchrei*	6.42	*Ficus microcarpa*	8.42
Desmodium uncinatum	4.02	*Brugmansia arborea*	4.39	*Macaranga tanarius*	5.64
Pneumatopteris nitidula	3.78	*Ficus septica*	3.80	*Litsea cordata*	4.57
Pogonatherum crinitum	2.91	*Ficus nota*	3.44	*Pterocarpus indicus*	4.43
Commelina diffusa	2.89	*Pennisetum purpureum*	3.18	*Triplaris cumingiana*	4.43
Setaria palmifolia	2.87	*Leucosyke benguetensis*	3.17	*Pittosporum pentandrum*	4.13
Downstream Stations					
Herbs	IV	Shrubs	IV	Trees	IV
Mikania cordata	9.45	*Dinochloa acutiflora*	49.45	*Pterocarpus indicus*	11.04
Ageratina riparia	8.21	*Acalypha amentacea*	9.53	*Commersonia bartramia*	11.03
Desmodium incanum	5.59	*Tithonia diversifolia*	6.98	*Ficus nota*	8.74
Drymaria cordata	3.85	*Mussaenda benguetensis*	4.27	*Ficus microcarpa*	8.42
Elatostema banahaense	3.74	*Leea guineensis*	3.52	*Litsea cordata*	8.27
Pennisetum purpureum	3.35	*Calliandra calothyrsus*	3.04	*Litsea glutinosa*	7.84

Chromolaena odorata	2.85	*Aralia bipinnata*	2.45	*Macaranga tanarius*	7.70
Selaginella plana	2.79	*Eurya coriacea*	2.45	*Bischofia javanica*	6.84
Oplismenus hirtellus	2.74	*Maesa indica*	2.16	*Pterospermum obliquum*	4.58
Odontosoria chinensis	2.62	*Cyathea contaminans*	1.78	*Aglaia cumingiana*	3.01