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MORPHOLOGICAL VARIATION OF LEAF PATTERN OF THE NEPALESE *TARAXACUM* SPP. (ASTERACEAE)

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ABSTRACT

Morphological variation of leaf pattern is very common in flowering plants to non-flowering plants that were used to differentiate the species in genus to species level. In this study, we used leaf morphology as the key characters to separate the species of Nepalese *Taraxacum*. Samples were collected from different parts of Nepal and herbarium specimen were observed to find the variation between the different species of *Taraxacum*. Our study shows that the presence of two distinct group in this genus *Taraxacum*. Taxa one is characterized by leaf with double margin (e.g. *Taraxacum eriopodum* along with 3 other species) and another group is characterized by leaf with single margin (e.g. *Taraxacum tibetanum* along with 5 other species).

Keyword: Morphology, leaf, taxonomy, venation

INTRODUCTION

The genus *Taraxacum* F.H.Wigg is the largest genus in the family Asteraceae that consists of 2814 species worldwide (APG-III 2009) and 14 species in Nepal (Hara *et al* 1976, Press *et al*, 2000). Genus *Taraxacum* lies in sub tribe Crepidinae under tribe Cichorieae of sub family Cichoriodeae (APG-III 2009, Xuejun Ge *et al* 2011). Mostly the species are distributed in the arctic and temperate zones of the northern hemisphere,with main diversity in mountains of Eurasia, a few species in temperate regions of the southern hemisphere (Xuejun Ge *et al* 2011). It is commonly called as 'dandelions' in the world.

In Nepal, the distribution of *Taraxacum* ranges from 720m to 4850m from east to west and from tropical region to alpine region (Malla 1976, Hara *et al* 1982, Polunin and Stainton *et al* 1984, Press *et al* 2000, Shrestha *et al* 2005, Xuejun Ge *et al* 2011). The distribution of many of the species is mainly concentrated on the central and western part than to the eastern region of Nepal.

Leaf pattern of flowering plants are studied around the world in terms of taxonomic identification, to understand the morphological variation based on different climate, to find out the size variation and so on. Leaf morphology is one of the most important visual part of

angiosperm which varies on different species of flowering plants to non-flowering plants. Although general and floristic studies of Asteraceae have been carried out extensively, investigations are yet inadequate of the genus *Taraxacum* from Nepalese Himalaya (Soest, J. L. van. 1960). This is a complex family for the taxonomic study and identification. However, none of the work has been done yet in Nepal. In the absence of molecular data and inaccessibility of the modern tool, this study will concentrate on morphological variation of leaf characteristics, in solving the taxonomic problems of the genus *Taraxacum* of Nepalese Himalaya. The key characteristics of leaf variation has been prepared for identification of different species of *Taraxacum*.

MATERIALS AND METHODS

Protologue and standard literature review

Protologue, the original material associated with a newly published name, consisting the description or diagnosis and any of number of other elements such as illustrations, synonyms and related literature were reviewed. All these provide the nomenclatural accuracy and species identification easier and also clarify the major taxonomic problems within a group. Different Floras like Hooker, J.D, 1882 (Flora of India), Grierson *et al* 2001(Flora of Bhutan), Xuejun Ge *et al* 2011(Flora of China) along with published research articles were reviewed for the identification of the species. Herbarium specimens were studied for complete documentation of different species within the genus.

Sample plant collection and preparation of herbarium specimens

We collected different species of *Taraxacum* from different parts of the country (the plant species were collected from Panchase, Ghandruk, Deurali, Ghorepani, Sikha, Jomsom, Muktinath, Parbatikunda, Dhunche to Gosainkunda starting from June to November 2017). Dried and perfect plant specimens were mounted on the standard size of herbarium paper 41.25 cm x 28.75 cm. Specimens were well mounted by using the glue, needle and thread. Small paper envelopes were attached to the sheet to hold seeds, extra flowers, or any part of the specimen. Unnecessary overlapping of leaves and other plant parts were removed.

Identification of specimens

The specimens were identified using standard literature (Van Soest 1961-63, Flora of Nepal, Hooker J.D 1882, Grierson et al 2001 and Xuejun Ge *et al* 2011) and further confirmed by examining with the herbarium deposited at National Herbarium Centre (KATH) and Tribhuvan University Herbarium (TUCH). Further, the plant specimens were also compared with the digital photographs of herbarium specimens of E (Royal Botanical Garden, Edinburg), BM (Bristish Museum, Digital image BM00003550, *Taraxacum nepalense* K (Royal Botanical garden ,Kew), TI (University Museum ,University of Tokyo), NHM (Natural Historical Museum). The literatures available and the main protologue texts were consulted for the further identification and confirmation of the species.

Morphological study

The collected herbarium specimens, herbarium at KATH, TUCH and ASCOL (Amrit Science Campus) were studied under the dissecting microscope for the respective species of *Taraxacum*. Morphological characteristics were observed and recorded for the vegetative characters including size, shape, and venation on leaf, leaf margin, and lobes. To study details for some parts, we also used light microscope, and dissecting microscope. For studying the

morphological characters, the plant parts were soaked in a detergent solution with ethanol and glycerol mixture in the ratio 1:10 which helps in the softening of the plants. The dissected vegetative parts were kept on a small paper envelope and attached on the sheet of the same respective herbarium specimens.

Illustrations

Free hand illustration of habit and leaf were made. Photographs of plants parts including vegetative parts of particular species were taken.

RESULTS

The leaves are simple, lobed, form a basal rosette above the central tap root and they are runcinate to pinnatisect (see table 1 and Fig. 1a, b). We found leaves are pinnately veined (Fig. 2 and3). Some species have pinnatisect to pinnatipartite leaf i.e *Taraxacum lanigerum.* All the leaves are found in the base so called rosullate. The shape of the leaves varies from species to species. Leaves are acute, lanceolate, obtuse or oblanceolate, subacute, subobtuse. The margin of leaves is entire, dentate, denticulate, and lanceolate. *Taraxacum amabile* have lanceolate type of margin whereas *T. pseudostenoceras* have denticulate type of margin**.** Most of the species have arachnoid or hairs at the base of the leaves and the petiole are unwinged (i. e. *T. eriopodum)* in many species and few are narrowly winged (i. e. *T. elegans)*. In most of the species, acute or obtuse leaf apices can be found. *Taraxacum lanigerum* have sub-acute leaves whereas *T. nepalense* have sub obtuse leaf.

Identification key for the genus Taraxacum based on leaf morphology

1a. Leaf double margin --------- 2 (*Taraxacum eriopodum, T.staintonii.,T.mucronulatum,T.nepalense)*
1b. Leaf single margin --------- 5 (*T. t i b e t a n u m , T. p a r v u l u m , T. l a n i g e r u m , T. pseudostenoceras,T.sikkimense,T.mitalii*)
2a. Margin entire, sparsely dentate --------- *T. eriopodum*
2b. Margin dentate --------- 3 (*T.nepalense, T.staintonii, T.mucronulatum)*
3a. Apex subobtuse mucronate ---------*T.nepalense*
3b. Apex subobtuse non mucronunate --------- 4 (*T. mucronulatum, T. staintonii*)
4a. Lateral lobes more than 5 ---------*T.staintonii*
4b. Lateral lobes 2-4 in number --------- *T. mucronulatum*
5a. Leaf apex narrowly acute --------- 6 (*T. lanigerum, T. pseudostenoceras, T. mitalii, T. sikkimense)*
5b. Leaf apex obtuse ---------9 *(T. tibetanum, T. parvulum)*
6a. Margin doubly dentate with 3 lobes ---------*T. pseudostenoceras*
6b. Margin dentate with more than 3 lobes ---------7 (*T. lanigerum ,T. sikkimense ,T. mitalii)*
7a. Leaf lobes strongly runcinate --------- *T. sikkimense*
7b. Leaf lobes 5 --------- 8 (*T. lanigerum,T. mitalii)*
8a. Lateral leaf lobes with recurved acute apex --------- *T. lanigerum*
8b. Lateral leaf lobes with subacute apex --------- *T. mitalii*

Table 1: Comparative study of leaves of *Taraxacum* species in the Nepalese Himalayas.

S. N.	Name of Species	**Leaf size** (length ± st. dev, cm)	(breadth± stdev, cm)	**Leaf shape**	**Leaf margin**	
					Lateral lobes	Terminal lobes
1	*Taraxacum eriopodum*	7 ± 4.24	2 ± 1.41	Oblanceolate	3-4 patent to recurved	Broader than lateral lobes
2	*Taraxacum lanigerum*	4 ±2.47	1 ± 0.71	acute, pinnatipartite to pinnatisect	4-8 lobes recurved	Short and broad dentate
3	*Taraxacum mitalii*	6 ± 4.24	0.3 ± 0.28	Pinnatisect	2-4 pairs, subacute.	Concave, short, few tooth
4	*Taraxacum mucronulatum*	8 ± 5.65	1.25 ± 1.06	Oblanceolate	2-4 pairs, triangular	Few
5	*Taraxacum nepalense*	6.5 ± 4.94	2 ± 1.41	Oblanceolate	3-5 pairs triangular	Short inner lobes
6	*Taraxacum parvulum*	5.5 ± 4.94	0.35 ± 0.21	Subacute,	3-5 pairs triangular	1 tooth or 1-3 denticels
7	*Taraxacum pseudostenoceras*	6.5 ± 4.94	1.25 ± 1.06	Deeply incised	5-6 pairs+_ lanceolate	1 dentate between lobes,doubly dentate with 3 lobes
8	*Taraxacum sikkimense*	4.75 ± 3.88	1.5 ±1.41	Oblong	3-4 pairs, recurved, strongly runcinate	Long, narrow terminal, triangular sagitate
9	*Taraxacum staintonii*	16.5 ± 16.26	3.5 ± 2.12	Broad lanceolate, leaves undivided	More than 5 lobes, sparsley denticulate	2-3 pairs narrow triangular
10	*Taraxacum tibetanum*	5.5 ± 4.94	1 ± 0.71	Narrowly oblong, lanceolate in outline.	2-4 pairs broadly triangular	Terminal lobe triangular

9a. Leaf blade dentate --------- *T.tibetanum*
9b. Leaf blade lanceolate --------- *T. parvulum*

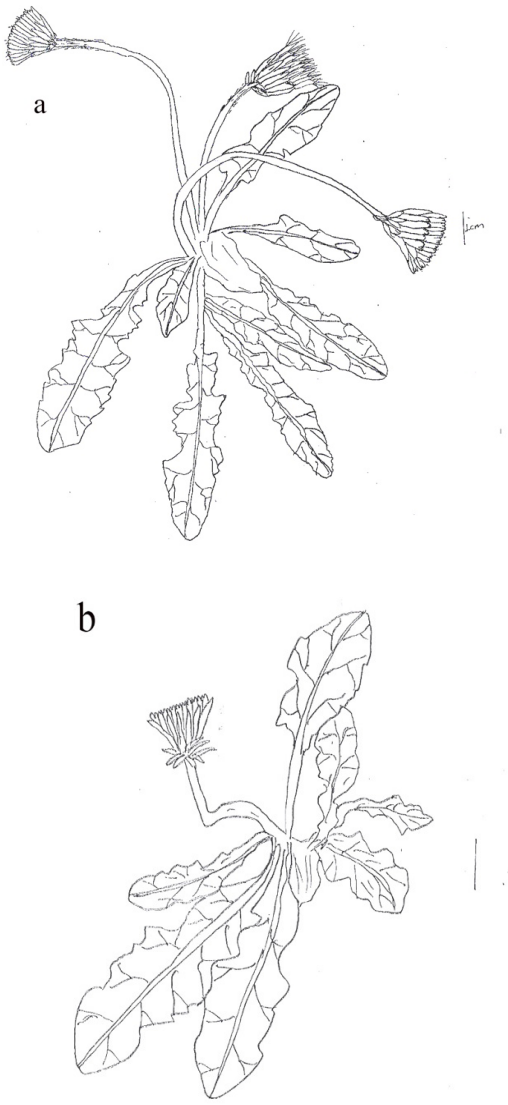

Figure 1. Example of habit sketch of *Taraxacum eriopodum (a)* and *T. parvulum* (b). Scale bar in the figure ×1cm.

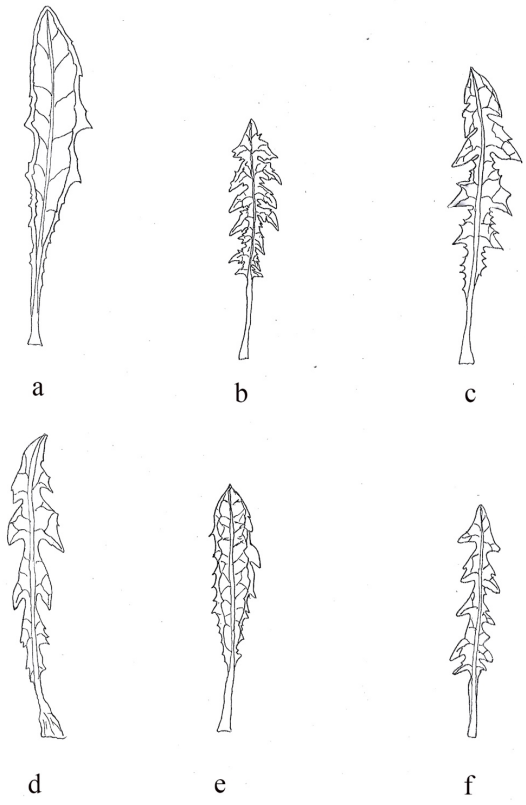

Figure 2. Diagrammatic sketch of leaf morphology of different species of *Taraxacum*. *a. T. mucronulatum* (×1cm), b. *T. lanigerum* (×1cm), c. *T. pseudostenoceras* (×1cm), d. *T.sikkimense* (×1cm), e.*T. nepalense* (×1cm), f. *T.mitalii* (×1cm).

DISCUSSION

The present study demonstrates that leaf morphology could be used as a new taxonomic parameter to identify and distinguish *Taraxacum* species. The result shows that the species are mainly separated first from double and single leaf margin. *Taraxacum eriopodum* has entire margin with sparsely dentate whereas *T. nepalense* having subobtuse and mucronate apex. *Taraxacum staintonii* has lateral lobes more than 5 whereas *T. mucronulatum* has 2-4 lateral lobes. *Taraxacum pseudostenoceras* has

margin doubly dentate with 3 lobes. *Taraxacum sikkimense* consists of leaf lobes strongly runcinate. The lateral lobes of *T. mitalii* has sub-acute apex whereas *T. lanigerum* has recurved acute apex. *Taraxacum tibetanum* has dentate leaf blade whereas *T. parvulum* has lanceolate leaf blade.

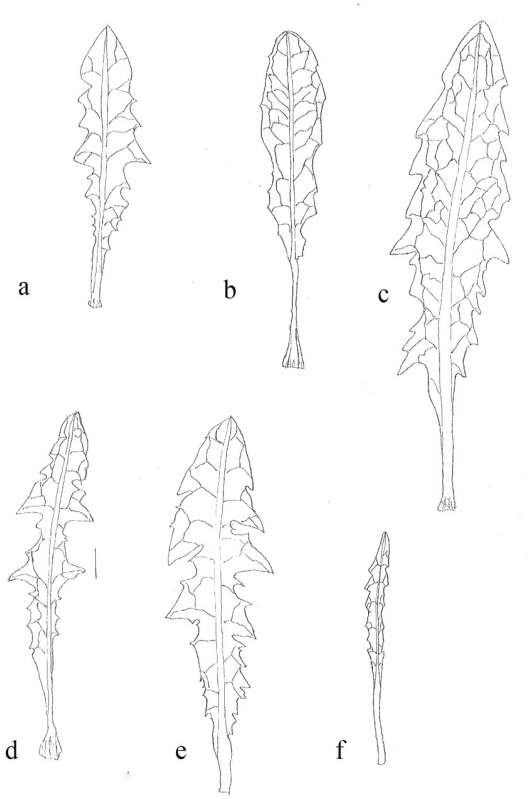

Figure 3. Diagrammatic sketch of leaf morphology of different species of *Taraxacum***.** a. *T. tibetanum*(×1cm), b. *T.eriopodum* (×1cm), c. *T.staintonii* (´ 2 cm), d. *T.parvulum* (×1cm), e. *Taraxacum parvulum* (×1cm), f. *Taraxacum parvulum* (×1cm).

Leaf morphology has been used for identification of different species and understand the evolution of flowering plants (Jones *et al* 2009, Romitelli and Martins 2013). For example, Jones *et al* (2009) studied the leaf shape morphology of South African *Pelargonium* species and suggested that different suites of leaf structure were used to determine the variation and identification key for this species. Teruro (2013) and his team studied the difference in leaf morphology of *Taraxacum* species of native and exotic species in Japan and found that leaf size is inconclusive to use to separate the species. However, our current work is focused on how leaf morphological variation can be used to distinguish the plant species. Future work will concentrate to understand the other characteristics features of *Taraxacum* along with leaf morphology to separate *Taraxacum* species in Nepalese Himalayas.

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