Present status and phytosociology of Critically Endangered *Streptocaulon sylvestre* Wight (Apocynaceae) in its only natural habitat in North Bengal University campus, India

Priyanka Das, Chandra Ghosh² and A. P. Das¹

Department of Tea Science, University of North Bengal, Darjeeling - 734013, West Bengal, India

¹Department of Botany, Rajiv Gandhi University, Rono Hills, Doimukh 791112, Arunachal Pradesh, India

(Formerly of: University of North Bengal)

²Communicating author, E-mail: amichandra07@gmail.com

[Received 26.04.2020; Revised 17.06.2020; Accepted 27.06.2020; Published 30.06.2020]

Abstract

After the re-discovery of *Streptocaulon sylvestre* Wight (Apocynaceae) interest grew for its conservation. The species has been declared as Critically Endangered (CR) by the Ministry of Environment & Forest, Govt. of India though attempt to its *in situ* conservation remained limited to the creation a '*Streptocaulon sylvestre* Reserve' (SSR) within the campus of North Bengal University on 31st December 2013. Previous attempts for its *ex situ* propagation, expansion of the area of occurrence and its domestication as a garden plant also were not positive. So it appears that the species should be conserved in *in situ* condition only under strict regular monitoring.

The present attempt of understanding the vegetation structure of the SSR was undertaken during a period when the seasons were not favourable for the better growth of most of the plants. Even then a rich diversity of flora of the reserve has been elucidated. The most dominant species in the reserve is *Cymbopogon pendulus* and some other associated species.

The present status of the species and the probable strategies for its maintenance-cum-conservation in its only known habitat has been discussed in this paper.

Key words: *Streptocaulon sylvestre*, Critically Endangered, Phytosociology, *In situ* Conservation

INTRODUCTION

The richness of the floristic diversity of Terai and Duars regions of West Bengal is well-known (Das 1995, 2013; Das *et al.* 2010). Large number of RET and endemic species are known to grow in this area and to conserve the biological diversity of this region quite a good number of Protected Areas (PA) are demarcated there and those are under operation (Das & Bhujel 2008; Sen & Mandal 2018; Das & Lungphi 2019). No doubt, these PAs are housing many important RET, endemic and economically exploitable species. But, at the same time, there are some such endangered species those are growing outside the PAs and needs immediate care and attention for their conservation.

Streptocaulon sylvestre Wight (Apocynaceae) is a small suffrutescent, strictly procumbent herb with milky latex that never gets rooted from branches. Originally collected by Fr. Buchanan Hamilton (Ham. Herb. No. 763; CAL) from the Sannyasikata village (Wight 1834; Das 1996) in the district of Jalpaiguri (West Bengal, India) on 7th of April 1809, the plant was doubtfully recognized by him as a species of *Periploca*. Later, in 1834 Robert Wight named it as *Streptocaulon sylvestre* (Wight 1834).

Streptocaulon sylvestre is one extremely rare plant and is reported to grow only in the foothill regions of Eastern Himalaya, namely Siliguri (Siliguree) and Sikkim Himalayas (Hooker

1883; Prain 1903; Watson 1999). The species has been declared as *Critically Endangered* (CR) by MoEF, Govt. of India, through the Gazette Notification no. S.O.769(E)-In exercise of the powers conferred by section 38 of the biological diversity Act, 2002 (18 of 2003), on 31st March 2010, by the Government of India (Figure 1; serial no. 2).

MINISTRY OF ENVIRONMENT AND FORESTS NOTIFICATION New Delhi, the 31st March, 2010	
S.O. 769(E).—In exercise of the powers conferred by section 38 of the Biological Diversity Act, 2002 (18 of 2003), the Central Government, in consultation with the Government of West Bengal, hereby notifies the species of plants and animals which are on the verge of extinction, as listed in column (2) of the Table below, for the State of West Bengal, namely :—	
TABLE	
Sl. No.	Name of the Species
(1)	(2)
Plants	
1	<i>Hibiscus fragrans</i> Romb.
2	<i>Streptocaulon sylvestre</i> Wight
Animals	
1	<i>Sus salvatica</i> (Hodgson, 1847)
2	<i>Cervus duvaucelii</i> (Cuvier, 1823)

Figure 1. MoEF, Govt. of India, through the Gazette Notification no. S.O.769(E).

With initiative of the senior author (APD), the North Bengal University authority has fenced one *Streptocaulon* rich area of about 7500 sq m for its *in situ* conservation in 2013. The area was then declared as the '*Streptocaulon sylvestre* Reserve' (SSR) and the species was provided with a vernacular name '*Uttara*' by the then Honb'le Vice-Chancellor Prof. Samir Kumar Das.

Phytosociology is the branch of science that deals with the plant communities, their composition and development, and the relationships between different species living together. This system is also used for classifying different plant communities (Paczoski 1896; Braun-Blanquet 1932; Poore 1955). In SSR the species is sharing the habitat with many other species including its preferred associates like *Borreria alata*, *Cymbopogon pendulus*, *Imperata cylindrica*, *Saccharum spontaneum*, etc. (Kadir 2001; Kadir & Das 2002; Kadir *et al.* 2009).

The species needs declaration as '*Pride of NBU*' as suggested by the then Secretary General of Botanic Gardens Conservation International in a personal communication to APD.

Why Endangered?

The main cause for a species to become endangered is the loss and disturbances of its natural habitat, mainly due to the expansion of human settlements and its related activities. In addition, there are some natural disasters like flood, forest-fire, over-powered by associated species, loss of preferred association, diseases and pest infestation, grazing of animals, etc. can also render a species endangered.

Streptocaulon sylvestre was never had a wide distribution and was endemic to Terai-Duars region of Bengal and Bihar (Das 1996), a region, that was covered with almost undisturbed vegetation even just 100 years earlier. Uncontrolled expansion of human settlements, tea garden, broad surface communication systems, etc. led to the extensive loss of natural habitat for the wildlife, both plants and animals in this entire area. The process has also affected the survival of *S. sylvestre* restricting it to about three acres area of the land inside the campus of the University of North Bengal. Due to different developmental activities of the University, it is now reduced to a small patch that is now SSR and another very small patch behind the Zoology Department building. However, physical searches since long in its previously known habitat, including the Type-locality at Snnyasikata failed to relocate its presence.

The experiments on the reproductive capacity of *S. sylvestre* shows that the rate of seed-germination is quite high but the rate of seedling survival is extremely poor and the micro-habitat preference is very strict (Kadir & Das 2007).

However, its population and growth inside the SSR is quite good. The present work was undertaken to understand the species richness of the SSR to characterise the vegetation type and to assess the present status of this Critically Endangered and endemic species of India. Also the generated data will be helpful to develop necessary strategies for its proper conservation.

Figure 2. Aerial photograph of North Bengal University campus (*source:* <http://www.nbu.co.org>)

METHODOLOGY

Study area

'*Streptocaulon sylvestre* Reserve' (SSR), which was established on the last day of the year 2013 (Anonymous 2014) and is located at the central sector of North Bengal University campus [26°42'20" to 26°43'20" N and 88°20'55" to 88°21'31" E] with an average altitude of c.130 m AMSL (Figure 2). The SSR area is situated on upland (terrestrial) and is now bounded by barbed wire fencing (beside Geology Department).

The drainage is good and never face water-logging. The maximum summer temperature varies between 35° C to 37° C and minimum winter temperature is c.7° C with average maximum and minimum atmospheric humidity 93.09 % and 57.14 % respectively. The annual average rainfall at the campus is 348.51 cm (Sharma 2007; Kadir *et al.* 2009). Previously the habitat-area was covered with the dense population of *Cymbopogon pendulus* and was suffering from fire almost every year.

According to Champion & Seth's (1968) classification of Indian Forest Types, the NBU Campus area was covered with mixed deciduous type of forest, dominated mainly by Saal (*Shorea robusta*). But, now, except a very small patch of Saal forest, located at around 80 m away from SSR, no other area is covered with natural forested vegetation inside or on surroundings of the campus.

Phytosociological Observation

The entire area of SSR has been surveyed phytosociologically using quadrat technique. As the habitat is a grassland, the standard quadrat size of 1 x 1 m has been employed for basic list-

PLATE I. *Streptocaulon sylvestre* Wight: **A.** Habit in natural habitat (covering grasses removed); **B.** SSR from a little distance; **C.** Axillary inflorescence with buds and open flower; **D.** Thick cover of *Cymbopogon pendulus* in October

count data. Sampling was done by semi-random quadrates on three equidistant line-transects. In the present study, a total of 100 quadrates have been studied for three seasons: Spring (February to March), Summer (April to May) and Monsoon (June to July) for the years 2016 and 2019 to achieve fair idea about the vegetation and its composition.

This list-count data is then processed to determine the second level data like RD, RF, RA and IVI (Mirsa (1966), Shimwell (1971), Tripathi & Mishra (1971), Phillip (1959), Das & Lahiri (1997), Kadir (2001) and Rai (2006)).

The species diversity and Species Richness of SSR were determined using the Shannon-Weiner Index (1963) and Menhinick's Index (1964). Also, the Concentration of Dominance of species and Similarity Index were determined by Simpson's Index (1949) and Sorensen's Index of Similarity (1968) respectively.

Shannon-Weiner Index (SDI):

Species Diversity Index [Shannon-Weiner Index] or SDI was calculated using the formula:

$$H' = - \sum [(n_i/N) \ln(n_i/N)]$$

[Where, 'H' is index value; 'n_i' number of individuals of a species; and 'N' total number of species in the habitat]

Species Richness [Menhinick's Index (1964)] with the formula:

$$D = S/\sqrt{N}$$

[Where, 'D' is the index value; 'S' total number of species; 'N' total number of individuals of all species]

Concentration of Dominance [Simpson's index, 1949] measured with following formula:

$$\bar{e} = \sum p_i^2$$

[where, 'e' is the index value; 'p_i' is the proportional abundance of the ith species

[P_i = n_i/N ['n_i' number of individuals of a species; 'N' total number of species in the habitat type]

Margalef indices (R₁) (Margalef 1968):

$$R_1 = S - 1 / \ln(n)$$

[Where, S = Total number of species; n = number of individuals of a species]

The voucher specimens were processed into mounted herbarium-sheets following Jain and Rao (1977/2016) and the identified using floras covering this region including Prain (1903); Hara (1966, 1971); Hara *et al.* (1978, 1979, 1982); Grierson & Long (1983 - 2001); Noltie (1994, 2000); Anonymous (1997, 2015, 2016) and by matching at the NBU-Herbarium. For up-dated nomenclature and for family delimitation www.plantsoftheworldonline.org has been consulted. These specimens will be deposited in the Herbarium of the Tea-Science Department of North Bengal University after the works are over.

RESULT

The result of phytosociological survey through quadrate sampling in the '*Streptocaulon sylvestre* Reserve' (SSR) inside the North Bengal University campus has been presented in Tables 1 – 3 for different study seasons. A total of 100 quadrates have been studied for three seasons to get fair idea about the vegetation composition.

Spring time vegetation: For the spring flora the vegetation was sampled during February – March and has recorded 28 species of plants. Analysis of the collected data has been presented in Table 1.

Table 1. Analysis of spring-season (February – March) data

[Abbreviations used: **RA** = Relative Abundance; **RD** = Relative Density; **RF** = Relative Frequency; **IVI** = Important Value Index. *Habit groups*: **C** = Climber; **H** = Herb; **S** = Shrub; **SH** = Suffrutescent Herb; **SS** = Suffrutescent Shrub; **T** = Tree]

TAXA	Habit	RA	RD	RF	IVI
<i>Ageratum conyzoides</i> L. [Compositae]	H	3.61	3.46	6.14	13.20
<i>Amaranthus blitum</i> subsp. <i>oleraceus</i> (L.) Costea [Amaranthaceae]	H	3.21	1.15	2.30	6.66
<i>Clerodendrum infortunatum</i> L. [Labiatae]	SS	4.27	8.36	12.53	25.16
<i>Cyanthillium cinereum</i> (L.) H.Rob. [Compositae]	H	1.80	0.29	1.02	3.12
<i>Cymbopogon pendulus</i> (Nees ex Steud.) W.Watson [Gramineae]	SH	13.17	42.07	20.46	75.70
<i>Crotalaria pallida</i> Aiton [Leguminosae]	H	1.44	0.06	0.26	1.76
<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob. [Compositae]	SS	4.44	2.31	3.32	10.07
<i>Desmodium triflorum</i> (L.) DC. [Leguminosae]	H	3.89	2.02	3.32	9.23
<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle [Euphorbiaceae]	S	3.37	0.40	0.77	4.54
<i>Ipomoea linearifolia</i> Hook. f. [Convolvulaceae]	C	1.44	0.06	0.26	1.76
<i>Imperata cylindrica</i> (L.) Raeusch. [Gramineae]	H	1.44	0.06	0.26	1.76
<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton [Apocynaceae]	C	2.41	0.29	0.77	3.46
<i>Leucas zeylanica</i> (L.) W.T.Aiton [Labiatae]	H	2.89	0.23	0.51	3.63
<i>Mikania micrantha</i> Kunth [Compositae]	C	2.89	0.23	0.51	3.63
<i>Mitracarpus hirtus</i> (L.) DC. [Rubiaceae]	H	3.05	1.09	2.30	6.44
<i>Mimosa pudica</i> L. [Leguminosae]	H	3.48	2.36	4.35	10.19
<i>Pueraria phaseoloides</i> (Roxb.) Benth. [Leguminosae]	C	3.66	1.90	3.32	8.89
<i>Premna mollissima</i> Roth [Labiatae]	T	3.25	0.52	1.02	4.79
<i>Pennisetum glaucum</i> (L.) R.Br. [Gramineae]	H	1.44	0.06	0.26	1.76
<i>Rungia pectinata</i> (L.) Nees [Acanthaceae]	H	9.34	13.43	9.21	31.98
<i>Streptocaulon sylvestre</i> Wight [Apocynaceae]	SH	4.26	6.80	10.23	21.29
<i>Sporobolus fertilis</i> (Steud.) Clayton [Gramineae]	H	5.91	7.32	7.93	21.16
<i>Senna tora</i> (L.) Roxb. [Leguminosae]	H	1.44	0.12	0.51	2.07
<i>Triumfetta rhomboidea</i> Jacq. [Malvaceae]	H	4.49	4.84	6.91	16.24
<i>Toona ciliata</i> M.Roem. [Meliaceae]	T	1.44	0.06	0.26	1.76
<i>Tridax procumbens</i> (L.) L. [Compositae]	H	2.89	0.12	0.26	3.26
<i>Trema orientale</i> (L.) Blume [Cannabaceae]	T	2.89	0.23	0.51	3.63
<i>Zanonia indica</i> L. [Cucurbitaceae]	C	2.17	0.17	0.51	2.85

Different indices calculated for the Spring-time vegetation are:

Simpsons Index: $1 = 0.44$

Menhinick Indices: $D = 0.67$

Margalef Indices: $R1 = 1.80$

Summer time vegetation: The quadrat sampling for summer data was conducted during April – May and has recorded 35 species. Analysis of the collected data has been presented in Table 2.

Table 2. Analysis of spring-season (April - May) data

[Abbreviations used: as for Table- 1]

TAXA	Habit	RA	RD	RF	IVI
<i>Amaranthus spinosus</i> L. [Amaranthaceae]	H	0.60	0.42	4.15	5.16
<i>Argyrea nervosa</i> (Burm.f.) Bojer [Convolvulaceae]	C	0.71	0.06	0.52	1.29
<i>Ageratum conyzoides</i> L. [Compositae]	H	1.00	0.79	4.66	6.46
<i>Bidens pilosa</i> L. [Compositae]	H	0.44	0.08	1.04	1.56
<i>Clerodendrum infortunatum</i> L. [Labiatae]	SS	0.39	0.17	2.59	3.15
<i>Crotalaria pallida</i> Aiton [Leguminosae]	H	0.63	0.39	3.63	4.65
<i>Cyanthillium cinereum</i> (L.) H.Rob. [Compositae]	H	0.18	0.02	0.52	0.71
<i>Cymbopogon pendulus</i> (Nees ex Steud.) W.Watson [Gramineae]	SH	1.37	2.41	10.36	14.15
<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob. [Compositae]	SS	28.87	27.94	5.70	62.51
<i>Desmodium triflorum</i> (L.) DC. [Leguminosae]	H	2.38	1.46	3.63	7.47
<i>Flueggea virosa</i> (Roxb. ex Willd.) Royle [Phyllanthaceae]	S	0.44	0.08	1.04	1.56
<i>Hyptis suaveolens</i> (L.) Poit. [Labiatae]	H	17.55	15.44	5.18	38.17
<i>Imperata cylindrica</i> (L.) Raeusch. [Gramineae]	H	0.71	0.12	1.04	1.87
<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton [Apocynaceae]	C	0.27	0.09	2.07	2.43
<i>Ipomoea linearifolia</i> Hook.f. [Convolvulaceae]	C	0.35	0.03	0.52	0.90
<i>Ipomoea quamoclit</i> L. [Convolvulaceae]	C	0.71	0.12	1.04	1.87
<i>Leucas zeylanica</i> (L.) W.T.Aiton [Labiatae]	H	0.18	0.02	0.52	0.71
<i>Litsea lancifolia</i> (Roxb. ex Nees) Fern.-Vill. [Lauraceae]	T	0.35	0.03	0.52	0.90
<i>Mikania micrantha</i> Kunth [Compositae]	C	0.41	0.11	1.55	2.08
<i>Mitracarpus birtus</i> (L.) DC. [Rubiaceae]	H	30.23	39.90	7.77	77.90
<i>Mimosa pudica</i> L. [Leguminosae]	H	0.53	0.19	2.07	2.79
<i>Pueraria phaseoloides</i> (Roxb.) Benth. [Leguminosae]	C	0.69	0.79	6.74	8.22
<i>Premna mollissima</i> Roth [Labiatae]	T	0.39	0.17	2.59	3.15
<i>Pennisetum glaucum</i> (L.) R.Br. [Gramineae]	H	0.50	0.26	3.11	3.87
<i>Rungia pectinata</i> L. [Acanthaceae]	H	0.26	0.20	4.66	5.12
<i>Streptocaulon sylvestre</i> Wight [Apocynaceae]	SH	0.40	0.28	4.15	4.82
<i>Sporobolus fertilis</i> (Steud.) Clayton [Gramineae]	H	4.89	6.88	8.29	20.06
<i>Senna tora</i> (L.) Roxb. [Leguminosae]	H	0.77	0.20	1.55	2.52
<i>Senna occidentalis</i> (L.) Link [Leguminosae]	H	0.65	0.17	1.55	2.37
<i>Trema orientalis</i> (L.) Blume [Cannabaceae]	T	0.35	0.03	0.52	0.90
<i>Triumfetta rhomboidea</i> Jacq. [Malvaceae]	H	1.57	0.97	3.63	6.16
<i>Toona ciliata</i> M.Roem. [Meliaceae]	T	0.35	0.03	0.52	0.90
<i>Tridax procumbens</i> L. [Compositae]	H	0.27	0.05	1.04	1.35
<i>Wrightia tinctoria</i> R.Br. [Apocynaceae]	T	0.35	0.03	0.52	0.90
<i>Zanonia indica</i> L. [Cucurbitaceae]	C	0.27	0.05	1.04	1.35

Different indices calculated for the Summer-time vegetation are:

Simpsons Index: $1 = 0.23$

Menhinick Indices: $D = 0.44$

Margalef Indices: $R1 = 0.82$

The monsoon data: The third round survey for the monsoon (June – July) vegetation recorded only 31 species and has been presented in Table 3.

Table: 3. Analysis of Rainy-season (June – July) data

[Abbreviations used: as in Table – 1]

TAXA	Habit	RA	RD	RF	IVI
<i>Ageratum conyzoides</i> L. [Compositae]	H	1.49	0.16	0.67	2.32
<i>Amaranthus spinosus</i> L. [Amaranthaceae]	H	1.19	0.21	1.12	2.53
<i>Argyrea nervosa</i> (Burm.f.) Bojer [Convolvulaceae]	C	0.10	0.04	0.22	1.25
<i>Bidens pilosa</i> L. [Compositae]	H	0.83	0.09	0.67	1.59
<i>Cymbopogon pendulus</i> (Ness ex Steud.) W.Watson [Gramineae]	SH	5.26	9.44	11.16	25.86
<i>Cyanthillium cinereum</i> (L.) H.Rob.	H	0.99	0.11	0.67	1.77
<i>Chromolaena odorata</i> (L.) R.M.King & H.Rob. [Compositae]	SS	2.08	2.02	6.03	10.13
<i>Crotalaria pallida</i> Aiton [Leguminosae]	H	1.77	1.27	4.46	7.50
<i>Clerodendrum infortunatum</i> L. [Labiatae]	SS	1.15	0.77	4.24	6.18
<i>Cuphea carthagenensis</i> (Jacq.) J.F.Macbr. [Lythraceae]	H	1.99	0.21	0.67	2.88
<i>Desmodium triflorum</i> (L.) DC. [Leguminosae]	H	4.85	6.10	7.81	18.76
<i>Eleutheranthera ruderalis</i> (Sw.) Sch.Bip. [Compositae]	H	1.97	1.99	6.25	10.21
<i>Hyptis suaveolens</i> (L.) Poit. [Labiatae]	H	7.42	7.73	6.47	21.62
<i>Imperata cylindrica</i> (L.) Raeusch. [Gramineae]	H	2.97	0.21	0.45	3.65
<i>Ipomoea quamoclit</i> L. [Convolvulaceae]	C	1.49	0.11	0.45	2.05
<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton [Apocynaceae]	C	1.38	0.45	2.01	3.84
<i>Leucas zeylanica</i> (L.) W.T.Aiton [Labiatae]	H	1.24	0.09	0.45	1.78
<i>Mitracarpus hirtus</i> (L.) DC. [Rutaceae]	H	30.22	43.43	8.93	82.57
<i>Murraya paniculata</i> (L.) Jack [Rubiaceae]	S	0.10	0.04	0.22	1.25
<i>Mimosa pudica</i> L. [Leguminosae]	H	1.60	0.80	3.13	5.53
<i>Pueraria phaseoloides</i> (Roxb.) Benth	C	2.02	2.18	6.70	10.90
<i>Rungia pectinata</i> L. [Acanthaceae]	H	2.19	0.95	2.68	5.83
<i>Streptocaulon sylvestre</i> Wight [Apocynaceae]	SH	1.18	1.02	5.36	7.56
<i>Sporobolus fertilis</i> (Stued.) Clayton [Gramineae]	H	9.93	16.41	10.27	36.62
<i>Setaria viridis</i> (L.) P.Beauv. [Gramineae]	H	2.16	0.23	0.67	3.06
<i>Senna occidentalis</i> (L.) Link [Leguminosae]	H	1.49	0.38	1.56	3.43
<i>Senna tora</i> (L.) Roxb. [Leguminosae]	H	2.41	0.52	1.34	4.26
<i>Triumfetta rhomboidea</i> Jacq. [Malvaceae]	H	4.19	2.86	4.24	11.29
<i>Trema orientalis</i> (L.) Blume [Cannabaceae]	T	0.10	0.11	0.67	1.77
<i>Wrightia tinctoria</i> R.Br. [Apocynaceae]	T	0.50	0.02	0.22	0.74
<i>Zanonia indica</i> L. [Cucurbitaceae]	C	0.10	0.04	0.22	1.25

Different indices calculated for the Spring-time vegetation are:

Simpsons Index: $1 = 0.20$

Menhinick Indices: $D = 0.41$

Margalef Indices: $R1 = 0.66$

Diversity Indices: The Simpson Index for Concentration of Dominance was observed at 51.78. The value is much higher (0.20) during June, followed by February and April at 0.23 and 0.44 respectively. The Species Richness value was calculated using Menhinick and Margalef indices. Average value of Menhinick Index for Species Richness shows 0.51. During February – March it showed a higher value of 0.67, followed by April (0.44) and June (0.41). Margalef index showed the average value of 1.09. February – March study showed much higher value with 1.80 and that was 0.82 in April and 0.66 in June. The species diversity and species richness of this vegetation is moderate with quite high concentration of dominance for the vegetation. This vegetation is quite diverse during post monsoon season. The species richness and concentration of dominance is quite high during April – June.

DISCUSSION

The Flora:

Phytosociological studies of the SSR in three different seasons has recorded the occurrence of 40 species of angiosperms, representing 18 families within the reserve. It is interesting to note that Monocotyledons are represented by only one family, i.e. Gramineae that too with only (five) species. Of the 18 recorded families, Compositae appeared as the highest represented family with as much as 07 species. It is then followed by Leguminosae (06 spp.), Gramineae (05 spp.), Apocynaceae, Convolvulaceae and Labiatae each with three species, Amaranthaceae

Table 4. Numerical distribution genera and species at the family level in SSR

Sl. no.	Family	No. of genera	No. of species
1.	Amaranthaceae	1	2
2.	Apocynaceae	3	3
3.	Acanthaceae	1	1
4.	Compositae	7	7
5.	Convolvulaceae	2	3
6.	Cucurbitaceae	1	1
7.	Euphorbiaceae	1	1
8.	Gramineae	5	5
9.	Leguminosae	5	6
10.	Labiatae	3	3
11.	Lauraceae	1	1
12.	Lythraceae	1	1
13.	Malvaceae	1	1
14.	Meliaceae	1	1
15.	Rubiaceae	1	1
16.	Rutaceae	1	1
17.	Ulmaceae	1	1
18.	Verbenaceae	1	1
	Total	37	40

with two species and the remaining (Acanthaceae, Cucurbitaceae, Euphorbiaceae, Lauraceae, Lythraceae, Malvaceae, Meliaceae, Rubiaceae, Rutaceae, Ulmaceae, Verbenaceae) 11 families are all represented with just single species (Table 4).

Table 5. Numerical representation of different habit-groups in the SSR

Habit Group	No. of Species	%
Climber (C)	6	15
Herb (H)	23	57.5
Shrub (S)	2	5
Suffrutescent Herb (SH)	2	5
Suffrutescent Shrub (SS)	2	5
Tree (T)	5	12.5
TOTAL	40	

The study was conducted mostly during the dry months and the flora was dominated with 23 species (57.5 %) of herbs, followed by Climbers with six (15 %) species, Trees with five (12.5 %) species. Shrubs, Suffrutescent Herbs and Suffrutescent shrubs all types are represented by only two (5 % each) species in the habitat. Out of five species of trees, four are represented by seedlings only, i.e. behaving like herbs. Only one stand of *Premna mollissima* is adult and growing inside the study area (Table 5).

Table 6 shows the five species with higher IVI scores and shows that *Cymbopogon pendulus* is the most important associated species for *S. sylvestre*. During February–March when most of the annuals remain in hibernation (in seed condition), some early showers helps *C. pendulus* to sprout with new leaves that was devoid of aerial parts during December – January. Many other plants also try to regenerate during this season including *Rungia pectinata*, *Clerodendrum infortunatum* etc.

Table 6. Five species with high IVI scores in the Spring-time (February – March) vegetation [Abbreviations used: as in Table 1]

	TAXA	RA	RD	RF	IVI
1.	<i>Cymbopogon pendulus</i>	13.17	42.07	20.46	75.70
2.	<i>Rungia pectinata</i>	9.34	13.43	9.21	31.98
3.	<i>Clerodendrum infortunatum</i>	4.27	8.36	12.53	25.16
4.	<i>Streptocaulon sylvestre</i>	4.26	6.80	10.23	21.29
5.	<i>Sporobolus fertilis</i>	5.91	7.32	7.93	21.16

Table - 7. Five species with high IVI scores in the Summer-time (April – May) vegetation [Abbreviations used: as in Table 1]

	Taxa	RA	RD	RF	IVI
1.	<i>Mitracarpus birtus</i>	30.23	39.90	7.77	77.90
2.	<i>Chromolaena odorata</i>	28.87	27.94	5.70	62.51
3.	<i>Hyptis suaveolens</i>	17.55	15.44	5.18	38.17
4.	<i>Sporobolus fertilis</i>	4.89	6.88	8.29	20.06
5.	<i>Cymbopogon pendulus</i>	1.37	2.41	10.36	14.15

With increased ambient temperature and precipitation many therophytic plants now produce dense population over the area during April – May (Table 7). Due to their extremely high population structure, *Mitracarpus hirtus* becomes strongly dominating. The situation prevails almost same during June – July (Table 8) rendering *Mitracarpus hirtus* as the most dominating species.

Table 8. Five species with high IVI scores in the Monsoon-time (June – July) vegetation. [Abbreviations used: as in Table 1]

	Taxa	RA	RD	RF	IVI
1.	<i>Mitracarpus hirtus</i>	30.22	43.43	8.93	82.57
2.	<i>Sporobolus fertilis</i>	9.93	16.41	10.27	36.62
3.	<i>Cymbopogon pendulus</i>	5.26	9.44	11.16	25.86
4.	<i>Hyptis suaveolens</i>	7.42	7.73	6.47	21.62
5.	<i>Desmodium triflorum</i>	4.85	6.10	7.81	18.76

However, during all these three study seasons, *Cymbopogon pendulus* achieved the highest score of IVI. It is also observed within SSR and outside the SSR that *S. sylvestre* always prefer to remain associated with *Cymbopogon pendulus*. Its population without this grass do not show good health.

This vegetation is quite diverse during post monsoon season. The species richness and concentration of dominance is quite high during April – June.

However, considering the calculated diversity indices it is realized that the vegetation is highly diverse even though it is dominated by a tall grass, i.e. *Cymbopogon pendulus*. Another grass *Imperata cylindrica* also become tall, sometimes over 1 m and forms very close vegetation. Dicotyledonous plants like *Mitracarpus hirtus*, *Hyptis suaveolens* etc. also create very dense vegetation.

Conservation:

After the rediscovery of *Streptocaulon sylvestre* in 1990 the natural habitat of this small Critically Endangered angiosperm has been found to be degrading very fast (Das 1996). Quite a few buildings have been constructed on its natural habitat. Only a very small patch has been fenced for its *in situ* conservation. There is no separate fund for its maintenance. The habitat is maintained like a low herbland during the dry seasons, but turns into a mini-savannah during late and post monsoon seasons.

Previous attempts of the conservation of *Streptocaulon sylvestre* through germination, transplantation and micropropagation were failed. It was realised that the species should be conserved *in situ*. Realising this, the “***Streptocaulon sylvestre* Reserve**” has been created within the campus of North Bengal University. But, regular maintenance of the Reserve is very much essential and for with an operation fund need to be generated.

CONCLUSION

Though herbaceous, the vegetation of “*Streptocaulon sylvestre* Reserve” is quite dense and the grass population is also extremely high. After fencing the area, it is now protected from grazing and collection of fodder. Previously, this grassland was generally suffering from fire (Intentionally created) during dry season and that was maintaining a lower level of density of

the vegetation. Because with the increasing density of the vegetation, the amount of light reaching the soil surface considerably. And, *Streptocaulon sylvestre* is a strictly prostrate plant that generally remain partially covered with grasses.

So, it is essential to reduce the grass cover on the soil regularly during monsoon and in the flowering season of *Cymbopogon pendulus* i.e. from late September to the end of October. However, all the diversity data express the significance of interference on the natural habitat. Fencing the habitat is also one interference.

It is also interesting to note that the variations within the three sampling season is very less that may be due to the selection of the period that was from a dry and cold season (in February) to only the beginning of the rainy season. Numerous other species of annuals are expected to come up during monsoon and in autumn and early winter a herbaceous temperate vegetation generally develop in the NBU campus. With all those new comers, finally, the plant diversity of this relict vegetation is expected to increase considerably.

The attempts for its *ex situ* propagation and expansion of the area of occurrence and its domestication as a garden plant also were not positive (Kadir 2001). So, it appears that the conservation of *Streptocaulon sylvestre* is not an easy job. It should be conserved in *in situ* condition under strict monitoring.

LITERATURE CITED

- Ahmedullah, M. 2004. Endemism in the Indian Flor. *Flora of India*, Introduction Vol. Part II : Botanical Survey of India, Calcutta. Pp. 246 - 265 .
- Anonymous, 1997. 2015, 2016. *Flora of West Bengal*, Vols. 1 – 3. Botanical Survey of India, Kolkata.
- Awasthi, N. 1992. Addition to the Neogene flora of Kerala coast, India. *Geophytology* 10: 146 - 157.
- Braun-Blanquet, J. 1932. *Plant sociology* (Transl. G. D. Fuller and H. S. Conrad). McGraw-Hill, New York.
- Champion, H. G. & Seth, S.K. 1968. *A revised survey of the forest types of India*. Govt. of India Press, Delhi.
- Chatterjee, D. 1939. Floristic Patterns in Indian Vegetation. Proc. *Summer School of Botany*, Darjeeling, New Delhi.
- Chatterjee, D. 1939. Studies on the Endemic Flora of India and Burma *Journ. Asiat. Soc. Bengal Sci.*, 5(1): 19 - 68.
- Das, A.P. 1986. *On the floristic and palynological surveys of Darjeeling and the adjoining places* (Vols. 1&2). Ph.D. Thesis, University of Calcutta.
- Das, A.P. 1995. Diversity of Angiospermic Flora of Darjeeling Hills. In: Pandey, A.K. (ed.), *Taxonomy and Biodiversity*, New Delhi: CBS Publishers and Distributors, New Delhi. Pp. 118 – 127.
- Das, A.P. 1996. Rediscovery of *Streptocaulon sylvestre* wight-an endangered and little known endemic plant of eastern India. *J. Bomb. Nat. Hist. Soc.* 93(2): 320 – 322.
- Das, A.P. 2004. Floristic Studies in Darjeeling Hills. *Bull. Bot. Surv. India*. 46(1-4): 1 – 18.
- Das, A.P. 2013. The present status of the flowering plants of Darjiling and Sikkim. In: Asha Gupta (ed.), *Biodiversity Conservation and Utilisation*. Pointer Publishers, Jaipur. Pp. 83 – 96.
- Das, A.P.; Bhujel, R.B. & Lama, D. 2008. Plant Resources in the Protected Areas and

- Proposed Corridors of Darjeeling, India. In Biodiversity Conservation in the Kangchanjunga Landscape Eds. N. Chettri, B. Shakya & E. Sharma. ICIMOD, Kathmandu. Pp. 57 – 79
- Das, A.P. & Lahiri, A.K. 1997. *Phytosociological studies of the ground covering flora in different types of vegetation in Tiger Hill, Darjeeling district, West Bengal (India)*. *Indian For.* 123(12): 1176 – 1187.
- Das, A. P. & Lungphi, P. 2019. Floristic Studies vis-à-vis Medicinal Plants in the Eastern Himalaya – past and the present status. In: S.K. Tripathi, K. Upadhyaya & N. Hegde (eds.), *Medicinal Plants of India: Conservation and sustainable use*. Today & Tomorrow's Printers and Publishers, New Delhi. Pp. 39 – 56. ISBN: 978817096525
- Grierson & Long 1983 – 2001. *Flora of Bhutan including a record of plants from Sikkim and Darjeeling*. Volumes 1 & 2 (in 6 parts). Royal Botanic Garden, Edinburgh.
- Hara, H. (ed.) 1966, 1971. *The Flora of Eastern Himalaya*. 1st & 2nd Reports. Tokyo University.
- Hara, H.; Chatter, A.Q. & Williams, L.H.J. 1982, *An Enumeration of the Flowering Plants of Nepal*. Vol. III, London.
- Hara, H.; Stearn, W.T. & Williams, L.H.J. 1978. *An Enumeration of the Flowering Plants of Nepal*. Vol. 1. British Museum (Natural History), London.
- Hooker, J.D. 1872 - 1897. *The Flora of British India*, 7 Vols, L. Reeve & Co. Ltd., Ashford, Kent. London.
- Kadir, A.F.M. Manzur 2001. *Ecology of Subhimalayan Herblands in Darjeeling with Special Emphasis on Streptocaulon sylvestre Wight – an Endangered and Endemic Plant*. Ph.D. Thesis, North Bengal University, India.
- Kadir, A.F.M. Manzur & Das, A.P. 2007. Reproductive capacity and seedling survivability of *Streptocaulon sylvestre* Wight – an endangered and endemic plant of Eastern India. *Pleione* 1(2): 62 – 68.
- Kadir, AFM Manzur; Ghosh, C. & Das, A.P. 2009. Interspecific association between *Streptocaulon sylvestre* Wight and its associated species in sub-himalayan herbland of Darjeeling in India. In: *Advances in Plant Biology*, ed. S. Mandal & S. Bhattacharya. Binapani Educational Welfare Trust, Sriniketan, West Bengal. Pp. 195 – 208.
- Malhotra, S.K. 1973. Studies on the limestone vegetation of Saha sradhara near Dehra Dun- phytosociological studies: Importance Value Index. *Indian Flor.* 99(2): 102-115
- Misra, R, 1968. *Ecology Workbook*, Oxford & I.B.H. Calcutta.
- Mishra, R. 1971. Phytosociological studies of the crop-weed association of Varanasi. *J. Indian Bot. Soc.* 50: 142 - 150.
- Myers, N. 1988. Threatened Biotas: 'Hotspot' in Tropical Forests. *Environmentalist*, 8(3): 1 – 20.
- Nayar, M.P. 1980. Endemism and patterns of distribution of endemic genera (angiosperms) *Journ. Econ. Tax. Bot.* 1: 99 - 110.
- Nayar, M.P. 1996. *Hotspots of Endemic Plants of India, Nepal and Bhutan*. Thrivanthapuram, Kerala.
- Noltie 1994, 2000. *Flora of Bhutan: the Monocotyledons*. Vol.3, parts 1 & 2. Royal Botanic Garden Edinburgh
- Ohashi, H., (ed.) (1975): *The Flora of Eastern Himalaya*. 3rd Report. Tokyo University.
- Paczoski, Jozef 1896. Paczoski J. 1896. Przyczynek do historii badań flory krajowej. Pamiętnik fizyograficzny. – Warszawa. – T. XIV. – Dzia³ III. – S. 145 – 151.

- Phillips 1959. Method of vegetation study. Henry Holt and Co. Inc. New York, U.S.A.
- Poore, M.E.D.. 1955. The Use of Phytosociological Methods in Ecological Investigations: II. Practical Issues Involved in an Attempt to Apply the Braun-Blanquet System; *Journal of Ecology* 43(1): 245 – 269
- Prain, D. 1903. *Bengal Plants*. Vols. I & II. West, Newman & Co., London.
- Rai, U. 2006. *Characterization of Plant Biodiversity in Darjeeling Hills Using Remote Sensing Techniques*. Ph.D. Thesis, University of North Bengal.
- Samanta, A.K. 1998. *Taxonomical and Phytosociological Studies on the Angiospermic Climbers of Darjeeling and Sikkim Himalayas*. Ph.D. Thesis, University of North Bengal, Siliguri.
- Sharma, B. 2007. *Mapping the Distribution of Some Important Local Tree Species In The Campus of North Bengal University*. M. Phil Thesis, University of North Bengal
- Shimwell (1971). Description and classification of vegetation. University of Washington Press, Seattle
- Sen, K. & Mandal, R. 2018. Present Status of Terai and Duars Region Biodiversity. *International Journal of Science and Research* 7(4): 1507 – 1511. ISSN (Online): 2319-7064. DOI: 10.21275/ART20181812
- Tripathi, R.S. & Mishra, R. 1971. Phytosociological studies of the crop-weed association of Varanasi. *J. Indian Bot. Soc.* 50: 142-150.
- Watson, M.F. 1999. Streptocaulon Wight & Arn., In: Grierson, A.J.C. & Long, D.G. (eds.), *Flora of Bhutan*, Vol. 2, no. 2. Royal Botanic Garden, Edinburgh. Pp. 694 – 695.
- Wight, R. 1834. *Contributions to the Botany of India*. Parbury, Allen & Co., London.
- <http://www.theplantlist.org>
- <http://www.iucn.com>
- <http://www.nbu.co.org>