

## **Anther appendages and anther collar in Asteraceae and their taxonomic significance**

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### **Abstract**

Variation in micro-morphological characters of anther of 35 taxa belonging to 13 tribes of the Asteraceae has been studied in order to determine whether taxonomically useful traits can be identified. The shape of anther tip appendage varies from acute, ovate-acute, retuse, beak-like, obtuse, truncate, rounded, toothed, linear-oblong, flat, apiculate to narrowly apiculate. Length of anther tip appendage varies from 120µm (*Spilanthes calva*, *Eclipta prostrata*) to 740µm (*Erigeron multiradiatus*). Anther base appendages are present in all the studied taxa except in *Conyza canadensis* and *Bellis perennis*. Length of anther base appendages varies from 20 µm (*Ageratum conyzoides*) to 1250 µm (*Duhaldea cappa*). Anther base appendages are branched in *Echinops echinatus*, *Launaea aspleniifolia* and *Sonchus oleraceus*. Anther collar is cylindrical in majority of taxa except in *Chrysanthemum carinatum*, *Senecio hybridus* and *Senecio nudicaulis* where it is balusterform. A new observation is the finger-like projections which develop from the anther collar region of *Centaurea cyanus* and *Circium falconeri*. This feature has been observed only in the members of Cardueae.

**Key words:** Asteraceae, Anther morphology, taxonomic significance

### **INTRODUCTION**

Asteraceae (Compositae *nom. cons.*) is one of the largest families of flowering plants comprising of approximately 1600 genera and 25,000 species distributed on all continents except Antarctica (Funk *et al.* 2009). In Asteraceae, micro-characters have been utilized for systematic considerations by many authors (Bentham 1873; Sundberg 1985; Robinson 1981, 2009). Wetter (1983) has reviewed the use of androecial micro-characters for delimiting segregate genera of *Senecio*.

Anther tip appendage, anther tail or anther base appendages and filament collar are important micro-characters which have been utilized as an aid to the taxonomy of the tribes and genera in the Asteraceae (Roque *et al.* 2009). Anther tip appendage is more or less membranous sterile portion of the anther tip that represents a distal prolongation of anther connective. It can be wider than long, as long as wide as or longer than wide; toothed, apiculate, acute, retuse or obtuse. The bases of anther sacs/ thecas may bear tail like basal lobes or sterile appendages which are known as anther tail or anther base appendages. Pollen bearing portions of the anther sac bases often are prolonged as lobes proximal to the insertion of the anther collar (calcarate anther) or bear sterile appendages (caudate anthers). Two types of collar have been recognized: cylindrical (diameter of the collar and the filament proper are same) and balusterform (basal cells of the filament collar are enlarged so that the diameter of the collar at the swollen portion is greater than the filament proper) (Drury 1975). The shape of the collar has been found taxonomically useful in tribe Senecioneae (Drury 1975; Wetter 1983) and Eupatorieae (Robinson & King 1977). Sundberg (1985) presented an evaluation of the utility of micro-characters in delimiting genera in the tribe Astereae. Paria & Chinya (2002) studied micro-morphological characters in some taxa of the Asteraceae. Anther appendages or spurs have been proposed to provide an accessory function in anther dehiscence and pollen dispersal (Buchmann 1983; Hermann & Palser 2000; Han *et al.* 2008).

Since a comprehensive survey of micro-characters in Asteraceae tribes is lacking, the present communication describes variation in anther tip appendage, anther base appendages and anther collars and their systematic significance.

### **MATERIALS AND METHODS**

The collected floral heads were fixed in formalin-acetic-alcohol and subsequently preserved in 70% ethanol. Anthers were stained with safranin and were dehydrated through alcohol- xylene

series and mounted in DPX. Length of anther tip appendage, anther base appendages (anther tail) and anther collar were measured by ocular micrometer. Voucher specimens have been deposited in the University of Delhi Herbarium (DUH) (Appendix I). 34 taxa belonging to 13 tribes have been included in the present study (Table 1).

## RESULTS AND DISCUSSION

In the present study 34 species belonging to 31 genera, 13 tribes and 5 subfamilies of Asteraceae have been investigated. The shape of anther tip appendage varies from acute (*Cirsium falconeri*), narrow-acute (*Echinops echinatus*), beak-like (*Centaurea cyanus*), rounded-obtuse (*Gerbera jamisonii*), truncate or emarginate (*Duhaldea cappa*), soft-rounded (*Launaea aspleniifolia*), flat-rounded (*Eclipta prostrata*), apiculate (*Ainsliaea latifolia*), broad-acute (*Vernonia cinerea*) [Fig.1]. Length of anther tip appendage varies from 120µm (*Spilanthes calva*, *Eclipta prostrata*) to 740µm (*Erigeron multiradiatus*) [Table1]. In *Duhaldea cappa* (tribe Inuleae) the anther tip appendage is truncate (emarginate), a feature also observed by Anderberg (2009) in this species. But in *Blumea hieracifolia* and *B. sericea* (other members of tribe Inuleae) the anther tip is acute. In *Ainsliaea latifolia* (Pertyeae) apical anther appendage is apiculate. The members of tribe Cichorieae (*Launaea aspleniifolia*, *Sonchus oleraceus* and *Taraxacum officinale*) possess soft apical appendage. In all the Cardueae (*Breea arvensis*, *Centaurea cyanus*, *Cirsium falconeri*, *Echinops echinatus*) studied presently, anther appendage is acute. Paria & China (2002) have reported rounded (*Goniocaulon indicum*), obtuse (*Carduus edelbergii*) or apiculate (*Saussurea jacea*) anther appendage in the members of Cardueae. Scott (1985) reported that *Koanophyllon* and *Chromolaena* (tribe Eupatorieae) can be distinguished on the basis of anther appendages and involucre. The anther appendages of the former taxa are distinctly grooved, usually short and somewhat reflexed, while those of the latter are consistently longer than wide. In *Eupatorium adenophorum* and *Ageratum conyzoides* anther tip appendage are longer than wide (present study).

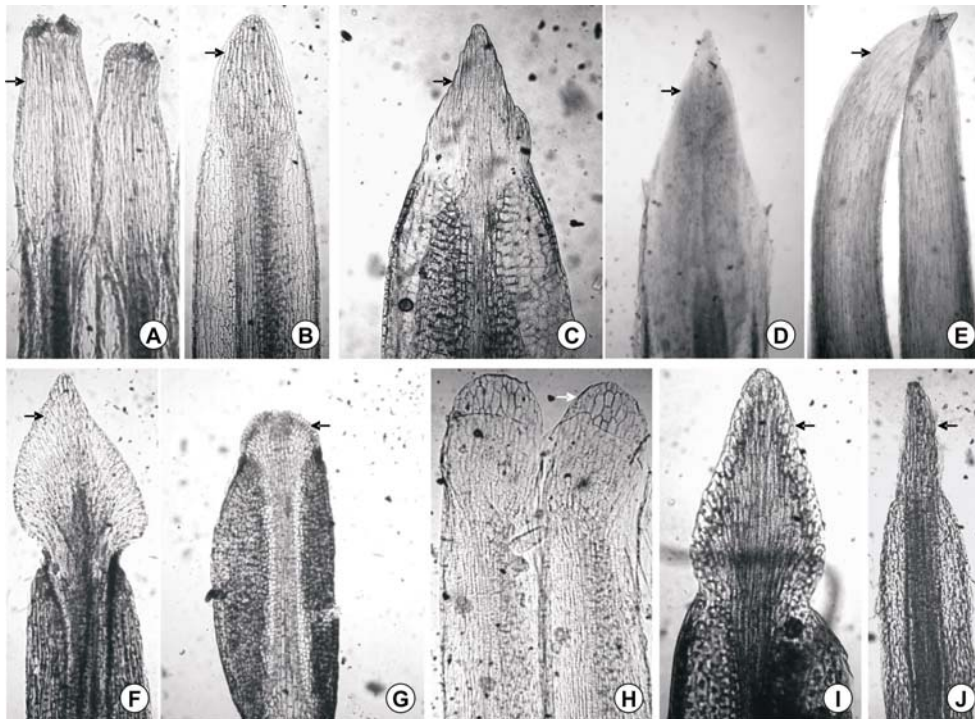
Anther base appendages are present in all the presently studied taxa except *Conyza canadensis* and *Bellis perennis* (tribe Astereae) where it is absent. Absence of anther tail has also been recorded by Brouillet *et al.* (2009) in most of the Astereae genera. Length of anther tail varies from 20 µm (*Ageratum conyzoides*) to 1250µm (*Duhaldea cappa*). Anther base appendages are much branched in *Echinops echinatus*, *Launaea procumbens* and *Sonchus oleraceus* (Fig. 2). The anther tail in Cichorieae is branched, calcarate and caudate. The anther tail in *Vernonia cinerea* and *V. pyramidale* (Vernonieae) is sagittate (present study). Paria & China (2002), however, reported sagittate anther base in *Vernonia cinerea* and tailed anther base in *Vernonia anthelmintica*, *V. elaeagnifolia* and *V. subsessilis*. According to Keeley & Robinson (2009) the anther base in members of Vernonieae is useful at sub-tribal and generic levels.

Two basic types of anther collar i.e., cylindrical and balusterform have been observed in the presently studied taxa. It is cylindrical in majority of the taxa except *Chrysanthemum carinatum* (tribe Anthemideae), *Senecio hybridus* and *Senecio nudicaulis* (of Senecioneae) where it is balusterform (Fig. 3). Based on micro-morphological characters, Wetter (1983) reported that cylindrical anther collars were restricted to the “Cacalioid” Senecioneae as defined by Robinson & Brettell (1973) and balusterform ones to the other Senecioneae. Nordenstam (1978) also found that cylindrical anther collars generally characterize “Cacalioid genera” but that they also occur in a number of genera traditionally associated with *Senecio*. He also found that balusterform anther collars characterized *Senecio sensu stricto* as well as many other more or less Senecioid genera and that the anther collars in *Serobicaria* had a tendency towards basal dilation forming a transition to the senecioid “type”. Though majority of Anthemideae show cylindrical anther collar but a pyriform anther collar (also called balusterform, Drury 1975 or senecioid, Wetter 1983) has been reported in *Artemisia capillaris* (Paria & China 2002). In the Astereae, the filament collar is usually about the same diameter as the rest of the filament but is swollen in some (but not all) species of *Lepidophyllum*, *Machaeranthera*, and *Aphanostephus* (Sundberg 1985).

**Table 1:** Anther tip appendage, anther tail and anther collar in some members of Asteraceae

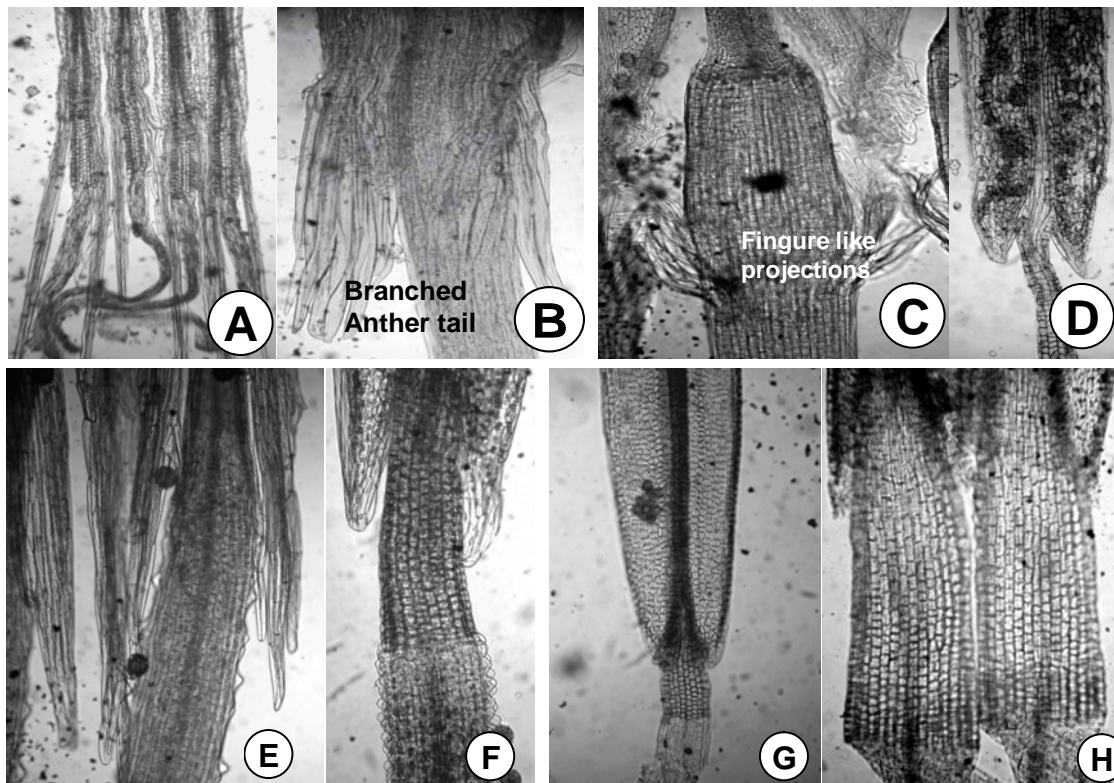
Taxa	Anther appendage		Anther tail		Anther collar	
	Shape	Length (µm)	Type	Length (µm)	Shape	Length (µm)
<b>Sub-family: Mutisioideae</b>						
<b>Tribe: Mutisieae</b>						
<i>Gerbera jamesonii</i> L.	Rounded-obtuse	630	Caudate	750	Cylindric	300 x 75
<b>Sub-family: Carduoideae</b>						
<b>Tribe: Cardueae</b>						
<i>Echinops echinatus</i> L.	Narrow-acute	560	Caudate	885	Cylindric	675 x 300
<i>Cirsium falconeri</i> Petr.	Acute	435	Caudate	230	Cylindric	765 x 150
<i>Centaurea cyanus</i> L.	Acute-like beak	315	Caudate	615	Cylindric	1170 x 300
<i>Breea arvensis</i> (L.) Less.	Acute	410	Caudate	770	Cylindric	680 x 280
<b>Sub-family: Pertyoideae</b>						
<b>Tribe: Pertyeae</b>						
<i>Ainsliaea latifolia</i> (D. Don) Schultz-Bipontinus	Apiculate	705	Caudate	915	Cylindric	740 x 215
<b>Sub-family: Cichorioideae</b>						
<b>Tribe: Cichorieae</b>						
<i>Launaea aspleniifolia</i> Hook.f.	Rounded	225	Caudate	610	Cylindric	220 x 75
<i>Sonchus oleraceus</i> L.	Rounded	155	Caudate	470	Cylindric	520 x 75
<i>Taraxacum officinale</i> Weber	Blunt-rounded	230	Caudate	600	Cylindric	435 x 135
<b>Tribe: Vernoniaeae</b>						
<i>Vernonia cinerea</i> (L.) Less.	Broad-acute	230	Caudate	22	Cylindric	155 x 45
<i>Vernonia pyramidale</i> (D. Don) S.N. Mitra	Acute	440	Caudate	350	Cylindric	200 x 80
<b>Sub-family: Asteroideae</b>						
<b>Tribe: Senecioneae</b>						
<i>Senecio hybridus</i> Regel	Acute-rounded	375	Caudate	150	balusterform	540 x 280
<i>Emilia sonchifolia</i> (L.) DC.	Narrow apiculate	225	Caudate	35	Cylindric	365 x 75
<i>Senecio nudicaulis</i> Buch. Ham. ex D. Don	Flat-rounded	225	Caudate	60	balusterform	345 x 185 -
<b>Tribe: Gnaphalieae</b>						
<i>Gnaphalium luteo-album</i> L.	Acute	50	Caudate	180	Cylindric	150 x 60
<i>Xerochrysum bracteatum</i> (Ventenat) Tzvelev.	Triangular	455	Caudate	240	Cylindric	606 x 144
<b>Tribe: Astereae</b>						
<i>Conyza canadensis</i> (L.) Carlquist	Narrow-apiculate	150	non-caudate	---	Cylindric	300 x 60
<i>Brachycome iberidifolia</i> Benth	Small beak-like	240	Caudate	50	Cylindric	300 x 75
<i>Erigeron multiradiatus</i> (Lindley ex DC.) C.B. Clarke	Small apiculate	740	Caudate	140	Cylindric	150 x 35
<i>Bellis perennis</i> L.	Narrow-apiculate	155	non-caudate	---	Cylindric	300 x 75
<b>Tribe: Anthemideae</b>						

Taxa	Anther appendage		Anther tail		Anther collar	
	Shape	Length (µm)	Type	Length (µm)	Shape	Length (µm)
<i>Chrysanthemum carinatum</i> Schousb.	Acute	375	Caudate	75	Balusterform	525 x 150
<b>Tribe: Inuleae</b>						
<i>Duhaldea cappa</i> (Ham.ex D. Don) A. Anderberg	Emarginate	460	Caudate	1250	Cylindric	420 x 105
<i>Blumea hieracifolia</i> (D. Don) DC.	Acute	300	Caudate	435	Cylindric	150 x 45
<i>Blumea sericea</i> Anderb. & A.K. Pandey	Soft-acute	345	Caudate	250	Cylindric	305 x 85
<b>Tribe: Tageteae</b>						
<i>Tagetes patula</i> L.	Acute	720	Caudate	180	Cylindric	620 x 260
<b>Tribe: Heliantheae</b>						
<i>Helianthus annuus</i> L.	Sagittate	465	Caudate	355	Cylindric	125 x 150
<i>Spilanthes calva</i> DC.	Sagittate	120	Caudate	75	Cylindric	150 x 60
<i>Bidens biternata</i> (Lour.) Merr. & Sherff.	Ovate-acute	430	Caudate	75	Cylindric	375 x 135
<i>Eclipta prostrata</i> (L.) L.	Flat-rounded	120	Caudate	70	Cylindric	225 x 90
<i>Galinsoga parviflora</i> Cavan	Acute	140	Caudate	80	Cylindric	160 x 85
<i>Parthenium hysterophorus</i> L.	Ovate-acute	145	Caudate	95	Cylindric	105 x 75
<i>Tridax procumbens</i> L.	Acute	375	Caudate	225	Cylindric	225 x 120
<b>Tribe: Eupatorieae</b>						
<i>Eupatorium adenophorum</i> Sprengel	Acute	220	Caudate	70	Cylindric	150 x 45
<i>Ageratum conyzoides</i> L.	Acute	150	Caudate	20	Cylindric	275 x 60

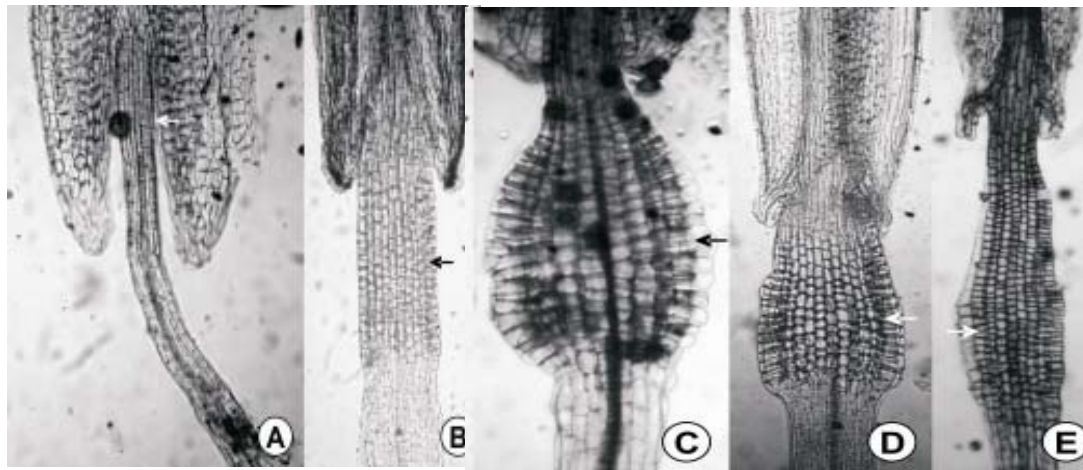


**Fig. 1.** Anther tip appendage in Asteraceae. A. *Duhaldea cappa*; B. *Senecio nudicaulis*; C. *Vernonia cinerea*; D. *Echinops echinatus*; E. *Centaurea cyanus*; F. *Bidens biternata*; G. *Parthenium hysterophorus*; H. *Launaea asplenifolia*; I. *Tridax procumbens*; J. *Ainsliaea latifolia*.





**Fig. 2.** Anther base appendages in Asteraceae: A. *Duhaldea cappa*; B. *Echinops echinatus*; C. *Centaurea cyanus*; D. *Eupatorium adenophorum*; E. *Cirsium falconeri*; F. *Tridax procumbens*; G. *Parthenium hysterophorus*; H. *Tagetes patula*



**Fig. 3.** Anther collar in Asteraceae. Cylindrical. A. *Vernonia cinerea*; B. *Bidens biternata*; Balusterform. C. *Senecio nudicaulis*; D. *Senecio hybridus*; E. *Xerochrysum bracetatum*.

In *Centaurea cyanus* and *Cirsium falconeri* (tribe Cardueae) finger like projections developed from anther collar region, a feature observed for the first time in this family. The papillae are larger in the former and smaller in the latter. The length and breadth of anther collar vary from 105 x 75  $\mu\text{m}$  (*Parthenium hysterophorus*) to 1170 x 300  $\mu\text{m}$  (*Centaurea cyanus*). In some Eupatorieae, both the collar shapes as well as the pattern of wall thickenings in the collar epidermis have proven to be of taxonomic value (Robinson & King 1977). In *Gnaphalium* anthers are caudate

and ecalcerate (present study). Ward *et al.* (2009) have recorded ecalcerate anthers in all the members of Gnaphalieae. Astereae is interesting as it shows both caudate and non-caudate anther tails (Table 1). Van Horn (1973) found that the length of the “connective prolongation,” or filament collar, had little taxonomic utility in distinguishing among *Pentachaeta*, *Chaetopappa*, *Tracyina*, and *Rigiopappus*. He surmised that, within the taxa treated, filament collar length was a reflection of the breeding system. In *Astranthium*, De Jong (1965) noted that “anther characters are too intangible to be of much value.”

The results of present study suggest that micro-characters alone are not sufficient to form a basis for taxonomic segregations. However, a combination of macro and micro-characters may be used for taxonomic delimitation within Asteraceae.

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## Appendix – I

### TAXA, LOCALITY, COLLECTOR NUMBER AND HERBARIUM ACRONYM

*Ageratum conyzoides* L., Pauri, Srinagar-Garhwal, SS & AKP 1008 (DUH); *Ainsliaea latifolia* (D. Don) Schultze-Bipontinus, Near Dhari Devi Temple, Srinagar-Garhwal, SS & AKP 1013 (DUH); *Bellis perennis* L., Khirsu, Srinagar-Garhwal, SS & AKP 1018 (DUH); *Bidens biternata* (Lour.) Merr. & Sherff., Delhi University campus, SS & AKP 1001 (DUH); *Blumea hieracifolia* (D. Don) DC., Buwakhhal, Pauri, Srinagar-Garhwal, SS & AKP 1016 (DUH); *Blumea sericea* Anderb. & A.K. Pandey, Bhimashankar, Maharashtra, AKP & Kumar 9237 (DUH); *Brachycome iberidifolia* Benth. Srikot, Srinagar-Garhwal, SS & AKP 1021 (DUH); *Breca arvensis* (L.) Less., Nandprayag, Srinagar-Garhwal, SS & AKP 1011 (DUH); *Centaurea cyanus* L., FRI campus, Dehradun, SS & AKP 1007 (DUH); *Chrysanthemum carinatum* Schousb., cult. Delhi University campus, SS & AKP 1002 (DUH); *Cirsium falconeri* Petr., Near Khirsu, Srinagar-Garhwal, SS & AKP 1024 (DUH); *Conyza canadensis* Carlquist, BSI campus, Dehradun, SS & AKP 1025 (DUH); *Duhaldea cappa* (Ham. ex D. Don) A. Anderberg, 4 km away from Khirsu, Srinagar-Garhwal, SS & AKP 1009 (DUH); *Echinops echinatus* L., Near Dewalgarh, Srinagar-Garhwal, SS & AKP 1014 (DUH), on the way to Bhimashankar, Maharashtra, AKP & Kumar, 9238 (DUH); *Eclipta prostrata* (L.) L., Timarpur, Delhi, SS & AKP 1003 (DUH); *Emilia sonchifolia* (L.) DC., Rudraprayag, Srinagar-Garhwal, SS & AKP 1017 (DUH); *Erigeron multiradiatus* (Lindley ex DC.) C.B. Clarke, near GNBN guest house, Srinagar-Garhwal, SS & AKP 1010 (DUH); *Eupatorium adenophorum* Sprengel, near HNB Garhwal University campus, Srinagar-Garhwal, SS & AKP 1012 (DUH); *Galinsoga parviflora* Cav., near Dhari Devi Temple, Srinagar-Garhwal, SS & AKP 1015 (DUH); *Gerbera jamesonii* L., near Buwakhhal, Pauri, Srinagar-Garhwal, SS & AKP 1019 (DUH); *Gnaphalium luteo-album* L., on way to Khirsu, Srinagar-Garhwal, SS & AKP 1027 (DUH); *Helianthus annuus* L., Srinagar-Garhwal, SS & AKP 1022 (DUH); *Launaea asplenifolia* Hook.f., near Shalimarbagh, Delhi, SS & AKP 1004 (DUH); *Parthenium hysterophorus* L., DU campus, Delhi, SS & AKP 1005 (DUH); *Senecio hybridus* Regel, Pipalkoti, Srinagar-Garhwal, SS & AKP 1023 (DUH); *Senecio nudicaulis* Buch.-Ham. ex D. Don, Pauri, Srinagar-Garhwal, SS & AKP 1030 (DUH); *Sonchus oleraceus* L., Binsar, Srinagar-Garhwal, SS & AKP 1028 (DUH); *Spilanthes calva* DC., on way to Chaupta, Srinagar-Garhwal, SS & AKP 1029 (DUH); *Tagetes patula* L., GNBN guest house, Srinagar-Garhwal, SS & AKP 1031 (DUH); *Taraxacum officinale* Weber, Near Rambara, Kedarnath, SS & AKP 1020 (DUH); *Tridax procumbens* L., on way to Triyugi Narayani, Srinagar-Garhwal, SS & AKP 1032 (DUH); *Vernonia cinerea* (L.) Less., FRI campus, Dehra Dun, SS & AKP 1026 (DUH); *Vernonia pyramidale* (D. Don) S.N. Mitra, on way to Chaupta, SS & AKP 1033 (DUH); *Xerochrysum bracteatum* (Vent.) Tzvelev., Delhi University campus, SS & AKP 1006 (DUH).