Chapter 2: Review of Literature

2.1 International Status

The Asteraceae family's large size makes its systematics difficult to understand. Though classification methods for this family are almost entirely 19th-century in origin, ideas about this family existed much earlier. Thus, Theophrastus (ca. 371–287 BC) marks the beginning of Asteraceae systematics research, which continues to this day.

The inflorescence of *Anthemis*, which has a rounded capitulum surrounded by leafy flowers (ray florets) with yellow florets inside, was identified by French botanist Jean in the 16th century, making him the first person to describe this family (Ruel 1536). Compositae were also described by John Ray in "*Herbae Florae Composito*" (1682) and Michael Adanson in "*Familles des Plantes*" (1763).

In "*Philosophia Botanica*", Carolus Linnaeus referred to this family as 'Compositi' (1751). In "*Praelectiones in Ordines Naturales Plantarum*," published in 1792, Paul Dietrich Giseke recorded Linnaeus' lectures and divided the Compositae into Tubuliflorae and Liguliflorae groups. Notably, Giseke's book was the first to publish a record of Compositae because it included a diagram illustrating the relationships between natural taxa. The accepted name "Asteraceae" was given by Ivan Ivanovich Martynov in his botanical dictionary "*Tekhno-Botanicheskii Slovar*" (1820).

In "*Institutiones Rei Herbariae*" (1700), Joseph Pitton de Tournefort was the first to categorize Asteraceae according to capitulum type, creating 35 distinct categories. Sébastien Vaillant (1719–1723) divided the Compositae family into Cichorieae, Cardueae, and other aster members, emphasizing flower sexuality and other characteristics such as phyllaries, receptacles, and pappus.

In his three-volume work "*Opuscules Phytologiques*" (1826–1824), Alexandre-Henri-Gabriel de Cassini made a significant contribution to the systematics of Asteraceae by providing the first tribal classification. Cassini also described a variety of characters and classifications for Asteraceae (Cassini 1813a, 1813b, 1813c, 1814, 1816a, 1816b, 1817, 1818a, 1818b, 1819a and 1819b). In addition, Cassini was the first to divide the Asteraceae into 20 tribes and identify the sister families of Boopidées (Calyceraceae) and Goodenoviées (Goodeniaceae) (1818b). His principles of classification included the impossibility of breaking up the family into a few large groups, the significance of stigma, style, and sweeping hairs, and the diagnostic features of hermaphrodite flowers.

In "*Synopsis Generum Compositarum*" (1832), Christian Friedrich Lessing placed a strong emphasis on style types and was the first to employ dichotomous Key for classifying genera and species. In "*Genera Plantarum*", George Bentham divided the Compositae into thirteen tribes (1873). With "*Die natürlichen Pflanzenfamilien*" (1890–1894), Karl August Hoffmann offered a classification up to the generic level, enumerating 806 genera and 108 illustrations.

James Small established himself as a pioneer when he suggested Senecioneae as the basal group and examined the phylogenetic relationships and origins of Asteraceae in "*The Origin and Development of the Compositae*" (1917). In his classification of Angiosperms, Arthur Cronquist (1955) considered both morphological and phytochemical characteristics. He proposed 12 tribes, the Heliantheae being the most primitive and the Cichorieae the last to evolve.

Kare Bremer pioneered the use of cladistics in classification, having worked extensively on the asteraceae taxonomic group. In his book "*Asteraceae: Cladistics and Classification*", he provided cladistics and a classification of the Compositae (Bremer, 1994). Bremer (1996) illustrated the relationships among the Compositae tribes. Asteraceae is classified into three subfamilies and seventeen tribes by Bremer & Jansen (1992) on the basis of corolla lobes, anthers and styles.

Table 2.1 Classification of Asteraceae by Bremer & Jansen (1992)

Family	Sub-Family	Tribe
Asteraceae	Barnadesioideae	Barnadesieae
	Cichorioideae	Mutisieae
		Cardueae
		Lactuceae
		Vernonieae
		Liabeae
		Arctoteae
	Asteroideae	Inuleae
		Plucheae
		Gnaphalieae
		Calenduleae
		Astereae

Family	Sub-Family	Tribe
Asteraceae	Asteroideae	Anthemideae
		Senecioneae
		Helenieae
		Heliantheae
		Eupatorieae

In more recent work, Funk *et al.* (2005) classified the Asteraceae family and created a super tree that includes every member of the family worldwide, with the exception of Antarctica. Vicki Funk investigated the phylogeny of Asteraceae anomalous taxa (Panero & Funk, 2008). "*Systematics, Evolution & Biogeography of Compositae*," a work published by Funk *et al.* (2009), includes a detailed analysis and evolution of each tribe within this family. The Asteraceae family has been categorized as follows by Funk *et al.* (2009):

Table 2.2 Classification of Asteraceae by Funk *et al.* (2009)

No.	Sub-Families	Tribes
1.	Barnadesioideae	Barnadesieae
2.	Stifftioideae *	Stifftieae
3.	Mutisioideae	Mutisieae, Onoserideae, Nassauvieae
4.	Wunderlichioideae *	Wunderlichieae, Hyalideae
5.	Gochnatioideae	Gochnatieae
6.	Hecastocleidoideae	Hecastocleideae
7.	Carduoideae	Dicomeae, Oldenburgieae, Tarchonantheae, Cardueae
8.	Pertyoideae	Pertyeae
9.	Gymnarrhenoideae	Gymnarrheneae
10.	Cichorioideae	Cichorieae, Arctotideae, Eremothamneae, Liabeae, Vernonieae, Platycarpheae, Moquinieae
11.	Corymbioideae	Corymbieae
12.	Asteroideae	Senecioneae, Calenduleae, Gnaphalieae, Astereae, Anthemideae, Inuleae, Athroismeae. **Heliantheae alliance:** Feddeeae, Helenieae, Coreopsideae, Neurolaeneae, Tageteae, Chaenactideae,

	Asteroideae	Bahieae, Polymnieae, Heliantheae, Millerieae, Madieae, Perityleae, Eupatorieae

2.2 National Status

According to Hajra *et al.* (1995), the Asteraceae family comprise 12 tribes and 167 genera, totaling nearly 900 species at the national level. Clarke (1876) published the first monograph in *Compositae Indicae*. Later, in Flora of British India, Hooker (1883) provided detailed accounts of Asteraceae, including 127 genera and 607 species divided into 13 tribes. Among the significant national studies conducted on Asteraceae by the Botanical Survey of India are Hajra *et al.* (1995) and Mao & Dash (2020). Some tribes, such as the Vernonieae tribe, have revised their taxa at the tribe and genus levels, encompassing nine genera, sixty-four species, one subspecies, and three varieties (Bhattacharjee *et al.*, 2019). A study was conducted on the three species of the Indian genus *Dolomiaea* DC., namely *D. baltalensis* Dar & Naqshi, *D. costus* (Falc.) Kasana & A.K.Pandey, and *D. macrocephala* DC. ex Royle (Kasana *et al.*, 2020). Shinde and Singh (2014) examined six genera and fourteen species within the Anthemideae tribe of Maharashtra. Singh & Kumar (2001) investigated the state of Sikkim's Asteraceae. The Anthemideae tribe of Jammu and Kashmir was covered in detail by Bhellum & Magotra (2013), who covered 11 genera and 47 species. Mamgain (1998) investigated the taxonomy, diversity, and ecology of the Indian Lactuceae tribe, encompassing 80 taxa and 10 genera. The 12 species of the *Inula* genus found in India were thoroughly studied by Shekhar *et al.* (2013). *Blumea* DC's Section Hieraciifoliae Randeria was examined by Dakshini (1978). Numerous other works also exist.

2.3 Gujarat Status

Asteraceae has not been thoroughly investigated at the regional level. It was limited to floras with numerous unresolved species and names, such as those described by Shah (1978), GEC (1996), and Raghvan *et al.* (1981). Consequently, monographic research will shed light on the Asteraceae's current situation in Gujarat.

2.4 Local Status

Major works in South Gujarat are included in floristic works such as Yadav's Flora of South Gujarat (1979). And in places like the Dangs (Suryanarayan, 1968; Tadvi, 2013), Valsad (Patel, 1971), Parnera Hills, Pardi and Udhwada (More, 1972), Vansda Forests (Desai, 1976),

Vapi and Umergaon (Contractor, 1986), Surat (Mac, 1982), and Dharampur (Reddy, 1987), local floristic works have been carried out.

Table 2.3 Summary of Asteraceae members reported in different works

No.	Literature	Tribes	Genera	Species
1.	World (Funk *et al.*, 2009)	43	1300	33000
2.	India (Hooker, 1883)	13	127	607
3.	India (Hajra *et al.*, 1995)	12	167	900
4.	Bombay Presidency (Cooke, 1904)	10	52	109
5.	Rajasthan (Shetty & Singh, 1988)	12	63	120
6.	Madhya Pradesh (Verma *et al.*, 1993)	12	62	106
7.	Maharashtra (Almeida, 2001)	14	103	206
8.	Gujarat (GEC, 1996)	13	53	101
9.	Gujarat (Shah, 1978)	12	53	90
10.	Flora of Saurashtra (Bhole and Pathak, 1988)	13	43	63
11.	South Gujarat (Yadav, 1979)	14	27	35
12.	Surat (Joshi, 1980)	13	33	40
13.	Surat (Mac, 1982)	12	35	46
14.	Basda or Vansda (Desai, 1976)	11	27	34
15.	Dang (Suryanarayan, 1968)	11	34	45
16.	Dang (Tadvi, 2013)	11	35	62
17.	Bulsar or Valsad (Patel, 1971)	12	32	38
18.	Valsad (Rao, 2015)	12	26	29
19.	Udwada, Pardi and Parnera (More, 1972)	13	37	43
20.	Dharampur, Kaprada and Nana Ponda (Vora, 1980)	13	32	38
21.	Vapi and Umargaon (Contractor, 1986)	11	30	37

2.5 Review of Pollen studies in Asteraceae

Palynological studies have significantly contributed to understanding the taxonomy, evolution, and ecology of the Asteraceae family, one of the largest families of flowering plants. Erdtman (1952), provided detailed descriptions of Asteraceae pollen, establishing key features such as tricolporate apertures and varied exine ornamentation and described Asteraceae as eurypalynous family. The exine ornamentation, ranging from echinate (spiny) to psilate (smooth), is a critical feature that helps in identifying genera and species. Subfamilial differences in pollen structure, such as the spiny exine of Carduoideae versus the smoother exine of Asteroideae, have been well-documented and used in taxonomic studies (Punt *et al.*, 1995).

Palynology has also provided key insights into the evolutionary relationships within Asteraceae. For example, pollen morphology has been used alongside molecular data to support the division of the family into subfamilies like Asteroideae and Cichorioideae (Bremer, 1994). The evolution of pollen types is linked to shifts in pollination strategies, with some genera adapting to insect pollination through spiny exines, while others have evolved smoother pollen for wind pollination. Fossil pollen records have further allowed researchers to trace the biogeographical history of Asteraceae, showing its likely origin in South America and subsequent spread (Martínez-Millán, 2010).

At the taxonomic level, pollen morphology has proven useful for species identification, especially in closely related genera where other plant traits may be less distinct. Tribe-specific studies, such as those on Anthemideae, Heliantheae, and Cardueae, have utilized pollen traits to refine taxonomic boundaries (Wagenitz, 1976). Additionally, fossil pollen from Asteraceae has been instrumental in tracking historical plant distributions and understanding vegetation changes during the Pliocene and Pleistocene epochs (Rull, 2003).

Palynological studies on the Asteraceae family in India have provided valuable insights into the taxonomy, biogeography, ecology, and allergy-related aspects of this large and diverse plant family. Asteraceae pollen, typically tricolporate with distinct exine ornamentation, has been a central focus for taxonomic research in India. Early works, such as those by Vasanthy (1976) on the tribe Heliantheae, revealed how variations in pollen size, exine sculpturing, and aperture types contribute to species identification and taxonomic classification. Similarly, Nair and Sharma (1965) provided detailed descriptions of the pollen morphology of *Helianthus* and *Tagetes*, emphasizing the importance of echinate exine in distinguishing *Helianthus* from other

genera. The pollen morphology of species within the tribe Vernonieae was also studied by Kumari and Nair (1979), who noted significant variation in exine ornamentation and aperture types across South Indian species of Vernonia.

Several studies have used palynology to resolve taxonomic ambiguities within the Asteraceae family in India. Chauhan and Rao (1990) conducted a palynological study of the genus Artemisia in the Himalayan region, identifying pollen characteristics such as size and aperture structure that differentiate species adapted to high-altitude ecosystems. Rao and Shukla (1977) examined Carthamus (safflower), demonstrating how pollen morphology varied with environmental conditions and how these traits helped distinguish closely related species. Pandey and Misra (2008) extended this approach to the tribe Eupatorieae in Central India, describing interspecies variation in pollen shape and aperture structure, which aided species-level identification.

Palynological studies on the Asteraceae family in Gujarat have focused on understanding the pollen morphology, taxonomy, and ecological adaptations of species in this region. One of the early studies on the palynology of Asteraceae in Gujarat was conducted by Trivedi and Soni (1986), who examined the pollen morphology of several species in the region. Their research focused on the tribe Heliantheae and noted significant variations in pollen size, shape, and exine ornamentation, which they correlated with environmental adaptations. They observed that species found in the arid and semi-arid regions of Gujarat exhibited smaller pollen grains with thick exine, a possible adaptation to wind pollination and harsh climatic conditions.

Subsequent studies by Patel *et al.* (1992) expanded the palynological research on Asteraceae in Gujarat by analyzing pollen grains of species within the tribe Anthemideae. They reported that the pollen grains in this tribe were predominantly echinate with tricolporate apertures, and the variations in pollen morphology were useful in distinguishing species within the tribe. The study highlighted the taxonomic importance of pollen characters in resolving species-level identification challenges within the region's diverse Asteraceae flora.