TAXONOMY OF CLEOME

_Cleome_ species were put earlier in family Capparidaceae. However, recently the genus has been given a separate status. It has been separated from Capparidaceae and grouped as Cleomaceae. Cooke (1903) has described ten species of _Cleome_ under Capparidaceae. One hundred and fifty _Cleome_ spp. have been so far described worldwide in tropical regions (Sharma and Balakrishnan, 1993) and fifteen species occur in India. Seven species are found to be distributed in the region of Kolhapur district (Yadav and Sardesai, 2002).

There are lots of observations on different parts of _Cleome_ species and some new species have been described continuously from past century by different authors. Diagnosen and Kleinere (1895) have reported a new species _Cleome schweinfurthii_. Kers (1968) has described _Cleome uncifer_ from Northwest Australia. _Cleome kersiana_ has been described and illustrated by Thulin (1992) from Somalia. Iltis and Ruiz (1997) have described endemic species _Cleome torticarpa_ from wet gallery forests National Park, Venezuela. Silva (2000) from Brazil reported _Cleome eosina_ J. F. Macbr. which was considered endemic to Paraguay. Reddy and Raju (2001) have reported _Cleome chelidonii_ var _pallai_ as a new variety from India. Keighery (2002) has discussed nomenclature and taxonomy of _Cleome uncifera_ and he separated it as a new subspecies using leaf morphology, a small-leaved variant species named _Cleome uncifera_ subsp. _microphylla_ Kers. and discussed ranges of variation in the leaves of the new and typical subspecies. Iltis (2005) has described and illustrated _Cleome boliviensis_ Iltis, with large-flowers, and discussed its relationship to other species.

Durand and Durand (1909) have described six species of _Cleome_ under Sylloge Flora Congolanae. Two new species, _Cleome viscosa, C. spinosa_ and also _Cleome gynandra_ have been described by Wilczek (1950) from Bas Katanga district. Blacklock (1955) has described upto 8 species of _Cleome_ from flora of Iraq and has given a separate key for their identification. Rao (1979) reported for the first time _Cleome rutidosperma_ from Andaman and Nicobar Islands. Weber _et al._ (1981) have added _Cleome serrulata_ to the flora of Colorado USA. Chamberlain _et al._ (1994) have recorded two new combinations and formal descriptions for eight new species and three new subspecies for the genera _Cleome, Polycarpacea, Silene, Gypsophila, Dianthus_ and _Rubus_ in Volume I of the Flora of the
Arabian Peninsula and Socotra. Siwakoti and Verma (1994) have reported *Cleome rutidosperma* DC. and *C. spinosa* Jacq. with other eighteen dicotyledonous taxa new to Nepal flora. Sivarajan and Sunil (1995) for the first time reported *Cleome spinosa* Jacq., in wild status from West Bengal, India (which is native of tropical America). Panda and Paul (2001) reported *Cleome aspera* Koenig ex DC. as a new record for Flora of West Bengal.

Khalifa and EL-Gohary (1982) studied micro morphological attributes like anatomical features of stem, leaves and petioles to evaluate their significance in differentiating the 9 *Cleome* spp. of Egypt. Lynne (1982) studied Cleomoideae and tried to explain their phylogeny by using cladistic method. Farris (1987) studied evolutionary change for several characters in *Cleome serrulata* Pursh and suggested that morphological characters had a greater impact on fitness in wetter areas, while physiological characters were more important in the drier areas. Mark et al. (1993) have studied different seed plants for their phylogeny and reported that the polyphyletics that occurs in capparidales is due to some members of capparaceae along with *Cleome*. Erbar and Leins (1997) studied floral ontogeny of *Cleome spinosa*, *Cleome violacea* and *Polanisia dodecandra* subsp. *Trachysperma* and concluded that the evolutionary steps in the androecial development proceed from *Reseda* via *Capparis* and *Polanisia/Cleome* to Brassicaceae. Sanchez (2005) tried to investigate phylogenetic and morphological relationships within, South American *Cleome* species. This study supported the monophyly of *Cleome* and the recognition of three clades within it, which are supported morphologically by seed and pollen characters. In general, seed and, to a lesser extent, pollen characters were found to be systematically useful within *Cleome* species.

Many workers have studied pollen morphology of different *Cleome* species. Pope (1925) studied pollen colours in different families and concluded that colour of pollen grains is almost constant in almost all members of a particular family with few exceptions. He studied *Cleome* and observed green coloured pollens in it. Mitra (1970) has studied pollen morphology in some *Cleome* species. Solomon et al. (1973) studied the pollen morphology of *Cleome serrulata* and reported that they are prolate, tricolporate, tectum reticulate with micropunctate lamina. Flint and Martyn (1982) worked on pollen germination and they mentioned that when UVB was administerd a large and significant inhibition of pollen germination was noted in *Cleome lutea*. Palacios et al. (1986) studied the pollen grains of three taxa belonging to family Capparidaceae, *Cleome multicaulis*, *Cleomella mexicana* and
Polanisia uniglandulosa and suggested that the species could be separated on the basis of the characteristics of seeds such as the ornamentation, apertures and shape. Ruiz et al. (1997) examined pollen morphology of 19 Cleome species from Venezuela using scanning electron microscopy and concluded that exine sculpturing has diagnostic value within the genus and supports the classification of species and there is no relationship between exine sculpturing and pollination syndromes. Silva (2000) reported that pollen grains of Cleome are tricolporate. Perveen and Qaiser (2001) investigated pollen morphology of 14 species belonging to seven genera of the family Capparidaceae viz., Cadaba Forssk., Capparis L., Cleome L., Dipterygium Decaisne, Gynandropsis DC., Maerua Forssk by using light and scanning electron microscopes. They concluded that palynology is significantly helpful at the specific level. Fagundez (2003) worked on melitopalynology of Cleome species coming from the flooded islands with the help of light and scanning electronic microscope. He for the first time identified Cleome hassleriana pollen sample from honey along with other plants also and studied importance of each taxon in the production of honeys of these areas.

Gier (1903) prepared a key for identification of herbaceous dicotyledons and studied the morphology of Cleome serrulata and reported the absence of stipules in it. Guedes (1968) studied morphology and anatomy of Cleome simplicifolia and for the first time he described the peltate petals in it. Puri (1971) studied the morphology of leaf and seeds of Cleome gynandra. Bhattacharya and Maiti (1978) from BSI studied seed morphology of 12 species of Cleome and prepared a taxonomic key for their identification through seeds only. Chakrabarty and Gupta (1981) have reported morphohistological characters of 3 herbaceous species growing along railway track including Cleome viscosa L. Sereno (1989) from Caribbean Barbados region has studied the morphology of Cleome tenuis. Ruiz and Escale (1995) studied seed morphology of 19 species of Cleome L. from Venezuela using the scanning electron microscope and observed seminal characters. Richard et al. (1997) described morphological details of Cleome isomeris and C. viscosa. Thulin (2002) has studied morphology of four species of Cleome in the Horn of Africa region and reported that C. omanensis, comb. nov. occurs in the Mahrah Region of Yemen and also in Oman and prepared a key for identification of the species.

According to Smith (1950) a gynophore is usually defined as stalk or stip which supports the ovary or gynoecium in certain flowers of Cleome. Vanderpool (1984) in
his studies on SEM of seeds of some *Cleome* species found the presence of stomates on the seeds. Lloyd *et al.* (1990) reported occurrence of heterostyly in S. African species of *Bauhinia* (Leguminosae), *Cleome* (Capparaceae), *Aneilema* (Commelinaceae), and *Agelaea* (Connaraceae). Koyama and Choshi (1996) have studied developmental stages of pistil in *Cleome spinosa*.

Rajendrudu *et al.* (1988) have studied leaf phylotaxy in *Cleome gynandra* L. Jelani *et al.* (1990) have described foliar dermotypes of the seven Indian species of *Cleome*, viz. *C. aspera* Koen. ex DC., *C. chelidonium* L.f., *C. felina* L.f., *C. monophylia* L., *C. gynandra* L., *C. tenella* L.f. and *C. viscosa* L. including epidermal cells, stomatal cells and trichome complexes. Six trichome types viz., uniseriate capitate, uniseriate cylindrical, biseriate capitate, multiseriate capitate, multiseriate clavate and multiseriate conical hairs have been observed. They prepared a key for identification of the species studied. Idioblastic cell sacs have been recorded in *C. aspera*, *C. chelidonium*, *C. felina* and *C. tenella*. It was also reported by them that though, *C. chelidonium* is a marshy plant, epidermal cells possess straight anticlinal walls. Changes in the foliar traits of some common plants including *Cleome viscosa* L. from polluted site were observed by Saha *et al.* (1990). They have reported significant variation in the palisade ratio and vein islet number in *Chromolaena odoratum*, *Cleome viscosa*, *Hyptis suaveolens* and *Xanthium strumarium*.

Raghavan (1937) Studied complete life history of *Cleome chelidonii* Linn. Weiss (1979) studied domestically used plants from East Africa which included *Cleome strigosa* and gave its traditional use. Sharma (1984) worked on systematic position of 11 angiosperm genera [*Atylosia*, *Centella*, *Cleome*, *Glinus*, *Ludwiglia*, *Malvastrum*, *Mukia*, *Pavonia*, *Spergula*, *Trachyspermum* and *Zaleya*] widely distributed in India. Vanderpool and Estes (1987) and Vanderpool *et al.* (1989) in their systematic investigation of *Cleome lutia* and *Cleome jonesii* concluded that these two entities are conspecific, each having n=17.

Rajagopal and Ramayya (1968) studied anatomy of *Cleome aspera* and found the occurrence of idioblastic cell-sacs in the leaf epidermis which is significant character for taxonomy of that plant. Iltis (1959) worked on taxonomy of *Cleome multicaulis* and described biogeography of this species. He (1960) studied monographic taxonomy and evolution of *Cleome gynandra*. Bremer and Wanntorp (1981) made an attempt to classify Cleomoidae cladistically. Brunel *et al.* (1984) worked on taxonomy of *Cleome* and prepared
a floral key for identification. Anuradha et al. (1988) worked on chemotaxonomy of Capparaceae and Cleomeae and found that there are close ties among the members of the two tribes. Subramanian and Susheela (1988) studied cytotaxonomy of 18 species coming under 6 genera of Capparidaceae and for the first time recorded chromosome number for some species. They concluded that the autopolyploidy and allopolyploidy play an important role in the origin and evolution of the species of South Indian Capparidaceae. Ruiz (2002) has given the taxonomic key for identification of Cleome with three species and other five genera from Capparaceae. Arbuzova and Nikitin (2003) studied taxonomy of Cleome and Cleomella-like fossil seeds from the Palaeogene and Neogene of Russia and adjacent states using scanning electron microscopy of the seed coat. Khatoon and Perveen (2003) studied Cleome heratensis Bunge subsp. pakistanica and raised it to the species level as Cleome pakistanica.
### Classification of *Cleome* in different systems

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#### Classification System: APG III

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#### Scientific classification

- **Kingdom**: Plantae
- **Division**: Angiosperms
- **Sub Division**: Dicotyledonae
- **Class**: Polypetalae
- **Series**: Thalamiflorae
- **Order**: Parietales
- **Family**: Capparidaceae
- **Genera**: *Cleome*
Botany

Day by day there is increase in knowledge about genus *Cleome*. Some common botanical features noted are as follows: Gray (1849) described *Cleome integrifolia* as cultivated ornamental plant with very beautiful flowers. Schaffner (1933) observed long stipitate condition of the gynoecium in some *Cleome* species which may cause sterility in them. Bancroft (1930) noted two species from genus *Cleome* and showed an indication of tetrarchy in hypocotyl. Frank (1948) has reported that *Cleome* is a source of surplus honey, so bees are attracted towards it. Rijven (1955, 56) observed that glutamine at concentration of 400 ppm stimulated the growth of embryos of *Cleome*. Acropetal dehiscence with complete department of the valves as well as basipetal incomplete dehiscence occur in the cleomoideae (Ernst, 1967). Amelaxen and Arbeiter (1969) indicated a cytoplasmic origin for the oil as secretory product of glandular hairs of *Cleome spinosa*. Thomas and Philips (1977) reported that leaf anatomy of *Cleome tenuis* indicated operation of C\textsubscript{3} metabolism.

Murneek (1927) studied andromonoecious reaction or process in *Cleome spinosa* L. Eames and Wilson (1928) studied anatomy and floral morphology of *Cleome spinosa*. Brink and Cooper (1947) studied embryonic development in *Cleome chelidonii*. Overbeek (1947) studied weed control by different synthetic chemicals. He reported that *Cleome* is controlled by spraying 2, 4, D in agriculture field. Ramanujam and Khatija (1991) studied melittopalynology of Guntur District Andhra Pradesh, India. A total of 66 pollen types referable to 38 families including *Cleome gynandra* have been recorded in these honey samples. Grzegorz and Maria (1998) investigated megafossils from the fluvial sediments overlying the Tertiary lignites in the Belchatów opencast mine of Middle Poland and recorded some genera (*Cleome, Ternstroemites* and *Zingiberoideophyllum*) which are new for the Tertiary of Poland.

**ECOLOGY**

Cook (1890) studied honey yield of *Cleome integrifolia* and other two plants and found that Rocky Mountain bee plant flourishes on the dry plains of Colorado, he had been quite successful in growing it and getting much nectar in small plots for years. Spring-sown seed will rarely germinate. So in the fall of 1888 he sowed eight acres of *Cleome* but he had great disappointment as the seeds did not germinate well.
Henri (1908) has recorded *Cleome integrifolia* as transient weed. Menon and Kulkarni (1987) have done ecological studies in *Cleome viscosa* with respect to seed and seed germination. Barker et al. (1990) recorded the vegetation on the campsite members occupied by different fast-growing, grazing-tolerant weeds like stoloniferous grass, *Cynodon dactylon*, and the non-palatable, annual forbs, *Cleome tenella* and *Gisekia pharnaceoides*. Ismail et al. (1995) recorded the occurrence of seeds belonging to 21 and 25 species in the rubber and oil palm plantations respectively, with *Asystasia gangetica* (L.) T. Anders., *Cleome rutidosperma* DC., *Borreria alata* DC. and *Paspalum conjugatum* Berg. being the most abundant in both plantations and accounting for more than 80% of the total weed seeds. Dickore and Nusser (2000) have reported *Cleome* as tropical weed in flora of Nanga Parbat. Lawrence (2001) identified *Cleome serrulata* and other eleven species of other genera commonly associated with corrals in Navajo. Merlee and Rekha (2002) studied *Cleome viscosa* for its autecology and provided information regarding its distribution and abundance which is helpful for its cultivation on a commercial scale. Ghaderian and Baker (2007) reported *Cleome heratensis* appears to be an indicator of ultramafics in Central Iran. Populations of this plant cover quite extensive areas during summer and autumn when there is no rainfall. This plant contained low concentrations of all metals and thus it possesses exclusion mechanisms to restrict excessive metal uptake.

Kassas and Zahran (1962) reported *Cleome drosorifolia* community in El Galata and El Bahariya. According to Iltis (1965) centers of *Cleome lanceolata* are Paraguay and Southwestern Brazil and NE Brazil. He (1967) studied ecological distribution of *Cleome afrospina* and its migration from South America to Africa or vice versa. Cook (1968) reported *Cleome ciliate* and *Cleome viscosa* vegetation from the Kainji reservoir site in Northern Nigeria. Leroy (1978) described 7 species of *Cleome* in which 3 species are endemic to Madagascar. Bruce (1989) studied phytogeography of sand dunes in great basin and Mojava desert. He reported *Cleome sparcifolia* as indicator taxa of all studied basins. Vegetation survey by Salama and Fayed (1989) revealed the following four community types in the wadis *Zilla spinosa - Aerva javanica, Pulicaria undulata-Schouwia thebaica, Cleome arabica* - *Crotalaria aegyptiaca* and *Acacia tortilis-Zygophyllum coccineum*. Salama and Fayed (1990) studied phytosociology of thirty nine species including *Cleome drosorifolia* for comprising the vegetation of the wadi using the Zurich Montpelliar technique. Ali et al.
(1997) recorded one hundred and ten species, belonging to 35 families during survey of the Wadi Allaqi. They found that among the recorded species, *Cleome paradoxa*, *Sesamum alatum*, *Gisekia pharnaceoides*, *Anticharis linearis* and *Anticharis arabica* are very rare in the Egyptian flora. This study showed that vegetation distribution in the studied area was largely dictated by environmental physiogeographic gradients that control the water availability in an extremely arid desert. Reddy *et al.* (2000) reported new naturalized *Cardamine trichocarpa* Hochst. ex A. Rich. and *Cleome rutidosperma* DC. in Andhra Pradesh, India. Nagar (2002) reported *Cleome scaposa* DC a rare species for Saurashtra. Galán de Mera *et al.* (2003) for the first time reported *Cleome violacea* L., *Puccinellia frigida* (Phil.) I. M. Johnst., *Sisymbrium altissimum* L. and *Solanum nitidibaccatum* Bitter from Peru. Waterhouse (2003) has given new distribution records for the serious tropical weeds *Chromolaena odorata* (L.) R.M. King & H. Rob. (Asteraceae), *Mikania micrantha* Kunth (Asteraceae), *Cleome rutidosperma* DC…. in northern Australia, Papua New Guinea and Papua (Indonesia). Barua *et al.* (2004) have described bioecological activities of *Leptosia nina* var *nina* Fabr, a common Pierid butterfly on *Cleome viscosa*. The ecological observations were carried out by them in the field to determine the status and distribution, habits and habitat, feeding, courtship, mating and egg-laying behaviour.

Sen and Chawan (1967) reported that *Cleome viscosa* grows vigourously in spring season. Abdul (1975) reported that *Cleome arabica*, an annual species is grown only in winter season. Singh *et al.* (1991) studied weed competition in green gram (*Vigna radiata*) and black gram (*Vigna mungo*) field and reported the following species during the monsoon seasons *Echinochloa colonum*, *Dactyloctenium aegyptium*, *Eleusine indica*, *Digitaria sanguinalis*, *Celosia argentea*, *Phyllanthus niruri*, *Cleome viscosa* and *Cyperus rotundus*.

Kers (1969) studied population ecology of *Cleome angustifolia*. The population ecology of *Cleome droserifolia* (Forssk) Del. was studied by Hegazy *et al.* (1990) in Egypt. Costa *et al.* (2002) described habitat, geographic distribution, morphological variability and prepared illustrations of different species of *Cleome*, for Brazil. They also prepared key for these species.

Hammerton (1981) reported *Cleome* spp. as weed and described common methods and chemicals used to control it. Wendy *et al.* (2007) provided Banana mulch treatment
method for control of annual weed species such as *Spermacoce latifolia* Aubl. and *Cleome aculeate* L. *Cleome* is a common plant found in tropical scrub habitat.

**BIOTECHNOLOGY**

Paigani And Romussi (1967) have analysed seeds of *Cleome pungens* using chromatography technique. They (1969) isolated feruloyl choline chloride from the seeds using the techniques like nuclear magnetic resonance, mass spectra, uv spectrum and IR spectrum. Koch *et al.* (2001) proposed that genus *Cleome* is closest relative of brassicaceae on the basis of molecular biology.

Naseem and Jha (1997) standardized *in vitro* protocol for mass propagation of *Cleome gynandra* DC, using thalamus, gynandrophore and root segments as explants on Murashige and Skoog's medium varying the concentrations of auxin and cytokinin. They observed that a high BA to NAA ratio produced leathery leaves in culture besides shoot differentiation. 2, 4-D was not suitable for organogenesis and long term culture. Regenerants were successfully transferred to soil. *In vitro* response of gynandrophore culture was almost similar to that of thalamus explant. Simoes *et al.* (2004) have done biotechnological studies in *Cleome rosea*. They studied the influence of cytokinins, 6-benzyladenine (BA) and 6-furfurylaminopurine (kinetin) added to the Murashige and Skoog medium (MS) on the culture and reported plantlet regeneration by direct and indirect organogenesis. Songsak and Lockwood (2004) established callus and suspension cultures from *Cleome chelidonii* to produce glucosinolates.

**CYTOLOGY**

There are few reports on cytology of *Cleome*. Talyor (1925) studied chromosomes in *Cleome spinosa* during mitosis. He recorded 32 chromosomes in the dividing cells (2n=32). Áskell (1976) worked on cytology of some members of capparidaceae. According to him the chromosomes number in some *Cleome* species is as follows. *Cleome gynandra* L. n = 17, *Cleome monophylla* L. n = 11, *Cleome serrulata* Pursh. n = 17, *Cleome rutidosperma* DC. n = 15, *Cleome viscosa* L. n = 10 and *Cleome coluteoides* Boiss. n = 17. But according to Raghavan and Kamble (1979) chromosome number in *Cleome gynandra* L. is n = 10. Renard *et al.* (1983) have reported chromosome number for three *Cleome* species, *Cleome monophylla* L. - 2n = 22, *C. schimperi* Pax - 2n = 22 and *C. gynandra* 2n = 34. Koshy and
Mathew (1985) worked on cytology of eight species of *Cleome*, indigenous to South India and concluded that chromosome data indicate that polyploidy and widespread aneuploidy may have played significant role in speciation and evolution of the genus. Wang *et al.* (2004) worked on cytology and micropropagation of *Cleome spinosa* Jacq. (2n = 20), and also studied germination and the young sprout growth of *Cleome spinosa* Jacq.

Farris (1987) investigated the extent and adaptive importance of genetically-based variation in plant water relations in two populations of *Cleome serrulata*. He collected seeds from maternal plants growing along the moisture gradients and then grew under well-watered conditions in the greenhouse. By his experiment he suggested that natural selection had acted on this character during one or more previous generations. It appears that slight variations in the physiological genotype can significantly affect overall fitness in *C. serrulata*.

Hegazy *et al.* (1990) investigated the autotoxic effects of *Anastatica hierochuntica* and possible effects on *Cleome droserifolia* and found that the mitotic index was reduced by 55% in *C. droserifolia* at the 8% level of the *A. hierochuntica* extract concentration. Naseem and Jha (1994) cultured callus derived shoot buds from younger leaves of the growing shoot of *Cleome viscosa* on Murashige and Skoog medium fortified with various combinations of 1-Naphthalene acetic acid (NAA) and 6-Benzylamino pure (BA). Rooting of shoots was obtained by using Indol-3-butyric acid in the medium and regenerated plantlets were subsequently transferred to the soil. Susana and Michael (2005) attempted gene sequencing in *Cleome hassleriana* using atpB and rbcL. Claudia *et al.* (2009) worked on cytogenetics and pigement composition of *Cleome rosea*. They cultured calluses using leaf and stem explant on MS medium supplemented with different concentrations of 2,4-dichlorophenoxyacetic acid (2,4-D) and from that eleven anthocyanins were obtained by using high performance liquid chromatography coupled to diode array detector and electrospray ionization mass spectrometry (HPLC-DAD/ESIMS).

**BIOCHEMISTRY**

Biochemistry of number of *Cleome* species has been studied extensively. Thirty eight species of *Capparidaceae* including *Cleome* had been analyzed for their content of isothiocyanate-producing glucosides for taxonomic significance of species and possible biogenesis of the glucosides (Kjaer and Thomsen, 1963). Chauhan and Srivastava (1979) have worked on some phytochemical aspects of the roots of *Cleome viscosa*. Rao (1980)
determined some characteristics of seed oil from *Cleome viscosa* and found that the seeds contain 26% oil. This oil is composed of 10.6% palmitic, 4.9% stearic, 14.4% oleic and 68.6% linoleic acids. Singh (1985) has studied leaf protines of *Cleome viscosa*. Kumar et al. (1985) have studied effect of isoproturon on leaf cell membrane permeability of *Cleome viscosa*. Cleomiscosin D, a minor coumarino-lignan of the seeds of *Cleome viscosa*, has been proved to be regioisomer of cleomiscosin C (Kumar *et al.*, 1988), and developed a method for degradation of coumarino-lignans.

Mnzava (1990) studied biochemical properties (Amino acid analysis, iodine and saponification numbers, crude protein, lipid, oleic and linoleic acids of the total fatty acids) of seeds of *Cleome gynandra*. Hussein *et al.* (1994) have worked on sesquiterpenes from *Cleome droserifolia*. Songsak and Lockwood (2002) reported that *Cleome chelidonii* and *Cleome viscosa* contain glucocapparin and glucocleomin, while *Cleome gynandra* has only glucocapparin.

Different workers have isolated different compounds from different *Cleome* species e.g. Kaempferide 3-glucuronide from the roots (Chauhan *et al.*, 1979); new naringenin glycoside (Srivastava *et al.*, 1979); three new coumarino-lignoids from the seeds (Ray *et al.*, 1985), which posses liver-protective properties (cleomiscosins A, B and C); stigmasta-5,24(28)-diene-3β-O-α-L-rhamnoside (Srivastava, 1980) and two new unsaturated cembrane acids (Kosela *et al.*, 1985) from *Cleome viscosa*. Cleosandrin from *Cleome icosandrica* (Nair, 1979); Cleomeprenols from *Cleome spinosa* L. which were identified as nonaprenol, decaprenol and undecaprenol (Suga and Shishibori, 1980). Viqar and Khisal (1986) have isolated cabralealactone and ursolic acid and new trinortriterpenoid dilactone, deacetoxybrachycarpone from *Cleome brachycarpa* by spectroscopic analysis. Ahmad and Alvi (1987) have isolated a cabralealactone, ursolic acid and new trinortriterpenoid dilactone, deacetoxy-brachycarpone from *Cleome brachycarpa* and determined its structure. Ahmad *et al.* (1990) isolated a new triterpenoid cleocarbpone from *Cleome brachycarpa*.

Sharaf *et al.* (1992) examined aerial parts of four *Cleome* species (*Cleome droserifolia, C. amplyocarpa, C. brachycarpa* and *C. chrysantha*) for their surface flavonoids content. Ten methylated flavonoids were isolated and identified as isokaempferide, 5,7,4'-trihydroxy-3,3'-dimethoxyflavone, Jaceosidin, penduletin, axillarin, 5,7,4'-trihydroxy-6,3',5'-trimethoxyflavone, chrysosplenetin, 5,3'-dihydroxy-3,6,7,4',5'-pentamethoxyflavone,
5,4'-dihydroxy-3,6,7,8,3'-pentamethoxyflavone and 5-hydroxy-3,6,7,3',4',5'-hexamethoxyflavone. Two triterpenes of the dammarane type compounds from aerial parts of *Cleome africana* were isolated and their structure was elucidated by Tsichritzis (1993) using high field NMR spectroscopy.

Hussein *et al.* (1994) isolated and identified some sesquiterpenes from *Cleome drosorifolia*. Harraz *et al.* (1995) have isolated 6 dormane terpenes from *Cleome ambylocarpa*. Ndungu *et al.* (1995) isolated the essential oil from *Cleome monophylla*. The identified constituents of this oil were evaluated and of these 14 compounds were identified by GC, GC-MS and coinjection with authentic samples. They have discussed the potential of *C. monophylla* against tick attack.

Sharaf *et al.* (1997) isolated and identified thirteen flavonoid glycosides from four *Cleome* and three *Capparis* species. Qin *et al.* (2000) isolated and elucidated new trinortriterpenoid, 1-epibrachyacarpone from *Cleome chrysantha*. Sogsak and Lockwood (2004) have isolated 2 volatile glucosinolate hydrolysis compounds in *Cleome chellidonii*. Tandon *et al.* (2010) studied and isolated cleomiscosins A, B and C from the seeds of *Cleome viscosa*. Chattopadhyay *et al.* (2011) have isolated the optically active nevirapine, a natural analogue of the previously designed and synthesized optically inactive nevirapine, a non-nucleoside inhibitor of HIV-1 reverse transcriptase from the seeds of *Cleome viscosa*.

Different diterpene derivatives are isolated from *Cleome*. Mahato *et al.* (1979) have isolated new diterpene lactone from *Cleome isosandrica*. Burke *et al.* (1980) isolated bicyclic diterpene cleomeolide from *Cleome viscosa* L. and established its stereo-structure by chemical, spectral and X-ray crystallography techniques. Jente *et al.* (1990) isolated a new macrocyclic diterpene (3E,7E,11E)-20-oxocembra-3,7,11,15-tetraen-19-oic acid (cleomaldeic acid), from *Cleome viscosa*. Mahato (2002) isolated Cleomeolide, a diterpene lactone from *Cleome icosandra* and reported that it may be used for therapeutic intervention in a wide range of diseases.

Seif *et al* (1984) have reported some flavonoids from *Cleome drosorifolia* which were identified as kaempferol-3-O-glucoside, rutin, kaempferol and luteolin-7-O-glucoside. Yang *et al.* (1990) reported five flavonoids from aerial parts of *Cleome drosorifolia* (Forssk.) Del. Mohamed *et al.* (1992) investigated ten methylated surface flavonoids from four *Cleome* species. Narendhirakannan *et al.* (2005) studied the anti-arthritic nature of *Cleome gynandra*.
L. against Freund’s complete adjuvant induced arthritis in rats and reported the presence of many biologically active phytochemicals such as triterpenes, tannins, anthroquinones, flavonoids, saponins, steroids, resins, lectins, glycosides, sugars, phenolic compounds, and alkaloids in the extract of *C. gynandra* and these compounds might be responsible for the anti-arthritic properties.

Leo *et al.* (1993) synthesized Cleomeolide, the structurally unique diterpene lactone constituent from *Cleome viscosa*. Fathalla *et al.* (1993) obtained four new and two known dammarane-type triterpenes from *Cleome amblyocarpa*. Hidekazu *et al.* (1997) obtained eighteen dammarane-type triterpenes from *Cleome africana*. Twelve of these were novel compounds. Nagaya *et al.* (1997) separated eighteen triterpene compounds from *Cleome africana*, in which twelve were novel.

Preliminary work by Zhang *et al.* (1993) revealed that dry seeds of *Cleome spinosa* evolve at least 24 kinds of volatile compounds into the ambient atmosphere during storage periods. The abundant production of butane was found in two kinds of tropical plants, *Cleome spinosa* Jacq. and *Cyperus alternifolius* L. The fact that the amount of evolved volatiles increases with increasing period or temperature of seed storage and suggests that these volatiles are produced metabolically even in dry seeds. They (1993) have found that the concentration of butane is high in *Cleome spinosa*. McLean *et al.* (1996) examined for the presence of betaines and other quaternary ammonium compounds in 55 species and varieties of Capparaceae distributed in 17 genera. It was found that prolinebetaine and/or 3-hydroxyprolinebetaine were detected in all the species of *Crataeva, Ritchlea, Maerua, Boscia, Capparis, Cladostemon, Cadaba, Thilachium, Morisonia* and *Steriphoma*, whereas glycinebetaine was only betaine found in *Cleome* species.

Ndungu *et al.* (1999) identified three constituents from the essential oil of *Cleome hirta* (phytol, (+)-cedrol, n-octacosane) and evaluated against the livestock tick, repellency and discussed potential of *C. hirta* in livestock tick and maize weevil control. Monica *et al.* (2009) identified one monoacylated and four diacylated cyanidin 3-sophoroside-5-glucosides as the main anthocyanins in flowers of *Cleome hassleriana* Queen Line.

Sawaya *et al.* (1985) have worked on chemical composition and nutritional quality of *Cleome dolichostyla*. Louda (1987) studied chemical changes in *Cleome serrulata*. He found that methylglucosinolate concentrations decreased significantly due to insect damage.
Khafagi (1998) developed heterotrophic callus cultures and photomixotrophic cultures from whole seedlings of *Cleome drosorifolia* and studied the effect of light and dark conditions on them and found that the heterotrophic callus cultures excreted allelochemicals (autotoxic) which inhibited callus induction and development. Mirza *et al.* (2005) studied essential oil of *Cleome iberica* DC. and found that it has 26 components. Constance *et al.* (2010) studied anthocyanin pigmentation pattern in petals of cultivated *Cleome hassleriana* Chodat and wild species, *Cleome serrulata* Pursh. (Rocky Mountain bee flower) and their relation with three genera of the Brassicaceae.

**PHYSIOLOGY**

Physiological studies in *Cleome* species are very rare. Zeevaart (1964) studied the effect of growth retardants on plant growth and development in many species. He observed that application of amo (2,12), CCC and phoston D caused delayed flowering in *Cleome* species. Vyas and Garg (1971) have studied interaction of GA and light on the germination and growth of seedlings of *Cleome viscosa*. de Jong and Bruinsma (1974) reported that application of ethylene and ascorbic acid resulted in inhibition of gynoecium in *Cleome iberidella*. Auxin transport inhibitor TIBA had no effect on corolla elongation while there was growth promotion by gibberellin.

Stephan (1984) showed that pollen grains of *Cleome lutea* can be germinated upto 57% on 15% sucrose medium. He also found an inhibition of pollen germination due to UVB radiation in number of plants including this species. Ochuodho and Modi (2005) have studied temperature and light requirement for seed germination in *Cleome gynandra*. They studied chilling, scarification, hydration and germination in the presence of KNO3 or GA (3) on the germination of seeds. They concluded that germination of seeds was improved by treatment with GA (3) and recommended that the germination should be performed under conditions of darkness and either alternating 20-30°C. Boonsong *et al.* (2009) investigated influence of seed maturity, seed storage and germination pre-treatments on seed germination of *Cleome gynandra*. They used different treatments (various levels of GA3, KNO3, leaching, pre-chilling, soaking and pre-heating at different temperatures) and reported that pre-heating at 40 °C for 1–5 days period was the most effective method for dormancy breaking. Rao *et al.* (1979) have studied the allelopathic effect of aqueous extracts of *Cleome viscosa* on the germination and early seedling growth of bajra.
Rajendrudu et al. (1996) studied growth of different plants (ecotypes) of *Cleome gynandra* L. that exhibits diapheliotropic leaf movements. The plants were grown at full (HI) and 40% (LI) natural irradiance. Sailaja et al. (1997) studied laser-induced F-685/F-720 chlorophyll fluorescence of intact leaves in solar tracking different plants including *Cleome gynandra*. It was found that the plant exhibited remarkable diurnal constancy in contrast and suggested that the leaves of diapheliotropic plants maximise light-use efficiency throughout the day and avoid the hazard of midday depression of photosynthesis.

Naidu et al. (1980) have studied photosynthetic pathway in some weeds including *Cleome gynandra* and *C. speciosa*. Rajendrudu and Rama (1982) could find some differences in the levels of dark respiration between C₃ and C₄ species like *Cleome gynandra*, L. C₄, *Cleome rutidosperma*, DC. C₃, *Cleome monophylla*, L. C₃ and *Cleome viscosa*, L. C₃. Higher rates of dark respiration and photosynthetic CO₂ uptake found in C₄ plants and in some C₃ species may form the basis for the rapid plant growth and biomass production per unit time in these species. They also studied carboxylating enzymes in the leaves of *Cleome gynandra*. They concluded that, the plant shows Kranz-type leaf anatomy and there was higher activity of PEP carboxylase in the whole leaf extracts than the other *Cleome* species. Brown et al. (2005) proposed that *Cleome* is very closely related genus containing C-4 species to the C-3 model *Arabidopsis* and may be used to accelerate our progress in elucidating the genetic basis of C-4 photosynthesis. Sawaya et al. (1985) analysed seeds of *Cleome dolichostyla* for mineral element contents, amino acid composition and *in vitro* protein digestibility and calculated protein efficiency ratio and concluded that seeds were rich (dry wt basis) in oil (32.1%), protein (24.6%) and fiber (17.8%). The amount of various mineral elements (mg/100 g) was Ca, 1970; P, 493; Mg, 127; Na, 35; K, 465; Fe, 71.97; Zn, 2.25; Cu, 0.44 and Mn, 1.45. Aspartic acid, glutamic acid, glycine, arginine and histidine were the major amino acids in *C. dolichostyla* seed. Badri et al. (1996) determined the mineral composition (Ca, Mg, K, Na, Fe, Al, Mn, Co, Ni, Cu and Zn) of *Senna alexandrina* and *Cleome droserifolia* in the Eastern Desert of Egypt. It was found that the concentration of Fe, Al, Mn, Co, Ni, Na and Si in the leaves of *Cleome* was always higher than that in the leaves of *Senna*. Edeoga et al. (2003) determined mineral and nutrient components like crude protein, crude fibre, carbohydrates, crude lipid, ash and food energy of leaves and stems of *Cleome rutidosperma*, along with other nine commonly used medicinal plants of Nigeria and suggested that these
medicinal plants could potentially be used as raw materials in drug formulation. Lottermoser et al. (2008) reported that the uptake of Cd, Pb and Zn by Cleome viscosa increases linearly with DTPA-extractable soil metal concentrations.

Dutt et al. (1984) worked on distribution pattern of free amino acids in Moringa concanensis, M. oleifera, Cleome chelidonii, C. gigantea, C. gynandra, C. monophylla, C. viscosa and Crataeva nurvula for systematic position of Moringa and concluded that Moringaceae shows almost no affinity to Capparaceae. Mnzava (1990) studied the seeds of Gynandropsis gynandra L. for their lipids, amino acids and proteins composition. Meyers (1995) compared Cleome serrulata and wheat for their protein content and concluded that protein content of Cleome serrulata is two times higher than that of wheat plants. Rathore and Meena (2004) have shown that leaves of Cleome viscosa contain 29.9% crude protein.

Selloum et al. (2004) studied antioxidative activity of Cleome arabica L. leaf extract by using superoxide anion radical generating systems. Narendhirakannan et al. (2005) tried to investigate the possible anti-oxidant potential of Cleome gynandra leaf extract on experimental rats and concluded that presence of biologically active ingredients and vital trace elements in the leaves readily account for free radical scavenging property of C. gynandra. Djeridane et al. (2010) screened 18 Algerian medicinal plants for their phenolic contents and radical scavenging activities and reported that the phenolic extract of Cleome arabica was the most effective. Compared to six other standard antioxidants (ascorbic acid, α-tocopherol, Trolox, (+) catechin, p-coumaric acid and gallic acid) the isolated compound was found to be significantly more active in the radical scavenging assay using 2, 2-diphenyl-1-picrylhydrazyl (DPPH).

Kumar et al. (1984) have worked on differential performance of Cleome gynandra and C. speciosa under water stress and their recovery conditions. When Cleome serrulata, growing at two sites (dry and wet sites) was studied for comparison, Farris (1988) found that morphological and growth characters were important for its fitness in mesic site, while physiological characters were more important in the dry site.

Importance of Cleome species:

Some of the Cleome species are widely used as food medicinal plants. Slosson (1888) reported Cleome speciosissima is cultivated for bee food as well as for flowers. Walter (1897) reported that Cleome integrifolia leaves boiled with green corn can be used as food.
Krochmal et al. (1954) studied many plants and reported that some Cleome species are eaten by Indian people as vegetable and obtain black dye from Cleome serrulata after boiling it in water. Odhav et al. (2007) collected preliminary nutritional data for traditional leafy vegetables in Kwa Zulu-Natal, South Africa. Twenty vegetables were studied for their content of mineral elements and antioxidant levels and all including Cleome monophylla recommended for future commercial cultivation.

Different Cleome species show different medicinal properties. Shabana et al. (1988) tested molluscicidal and cercaricidal activities of fifty-eight plants from 22 families and found lower molluscicidal effectiveness shown by extracts of Panicum turgidum, Calligonum comosum, Cleome amblyocarpa, Cornulaca monacantha, Silene villosa, Jasenia montana and Achillea fragrantissima. Saxena et al. (1992) tested 15 plants; four plant extracts showed anti-juvenile hormone against mosquitoes in the acetone extracts of Ageratum conyzoides, Cleome icosandra, Tagetes erectes and Tridax procumbens. They observed significant anti-juvenile property against mosquitoes only in Ageratum, Cleome and Tridax extracts. Loss of fecundity was observed in the treated mosquitoes but no sterilant effects could be recorded. Adults, obtained from larvae exposed to the plant extracts produced significantly shorter egg-rafts than in control. Smyth (1903) studied anthelmintic, antipyretic and tonic properties of Cleome serrulata. Ganesan (1994) studied antifungal properties of 30 plants against Drechslera oryzae and reported that the aqueous leaf extracts of Cleome aspera could effectively inhibit germ tube elongation. Perumalsamy and Raja (1996) studied antibacterial properties of aqueous extracts of some selected weeds including Cleome species. Ndungu et al. (1999) studied potential of essential oil of Cleome hirta and reported that three identified constituents (phytol, (+)-cedrol and n-octacosane) were evaluated against the livestock tick, and maize weevil. Lazzeri and Manici (2001) have studied fungitoxic activity of Cleome hassleriana. Stephan et al. (2001) have studied nematocidal activity of some Cleome species. They have reported toxicity of crude extract of different plants including Cleome against egg-masses of Meloidogyne javanica, a root-knot nematode and found that pre-planting application of Cleome extracts resulted in significant reduction in root-gall index and improved plant growth (dry shoot and root weights). Mothana et al. (2006) investigated Cleome socotrana as well as other 24 different plant species, for their antiviral activity. Nagarajan et al. (2005) studied activity of petroleum ether and benzene extracts of Cleome
felina on alloxan diabetic rats and concluded that this plant extract has antidiabetic and antihyperlipemic properties. Sharma et al. (2010) synthesized first time six novel cleomiscosin A and studied potent anti-inflammatory activity using primary macrophages cell culture bioassay system.

Gardiner and Brace (1889) reported medicinal properties of Cleome gynandra for relieving pain, curing skin diseases like leprocy and earache. Bedi (1978) noted that leaf juice of Cleome viscossa was used to remove pus from wound and leaf juice and oil from seeds of Cleome gynandra were used to cure skin diseases. Mpuchane and Gashe (1996) determined antibiotic sensitivity of Klebsiella isolates for Corchorus olitorius and Cleome gynandra. Shackleton et al. (1998) studied use and trading of Cleome gynandra in South Africa and reported that generally 82% people use Cleome gynandra in their diet in the Central Lowveld Savanna Region, and in winter, Cleome gynandra (usually dried) and Momordica balsamina were the principal herbs widely sold. Samy et al. (1999) studied antibacterial activity of 16 different ethnomedicinal plants along with Cleome gynandra and Cleome viscossa. These Cleome species were tested against three gram positive and seven gram negative bacteria by the filter paper disc diffusion method. It was found that the extract of these species significantly controls the growth of all bacteria. Zemede and Mesfin (2001) mentioned that Cleome gynandra is cultivated alongside other vegetables and black dye obtained from Cleome serrulata is two times higher than that from wheat plants. Hebbar et al. (2004) conducted ethnomedicine survey of the Dharwad district of Karnataka in southern India. They recorded 35 plants belonging to 26 families for their medicinal properties. They reported that Cleome gynandra is used to treat tooth ache. Narendhirakannan et al. (2005) worked on medicinal properties of Cleome gynandra L., which has traditionally been used for the treatment of rheumatic and other inflammatory conditions. Here they worked on checking significant anti-inflammatory activity in adjuvant-induced arthritic rats and demonstrated that the plant extract has no harmful effect and exerts in vivo anti-inflammatory properties against adjuvant induced arthritis. Modern Hopi people served Cleome gynandra L as an important starvation plant (Iltis, 2005). The antibacterial activities of Cleome gynandra were studied by Vijayakumar et al. (2005) against Escherichia coli, Proteus vulgaris and Enterobacter faecalis. Samuel and Brian (2007) reported use of Cleome gynandra as inter crop helpful for significant reduction of red spider mite (Tetranychus urticae Koch) in
greenhouse rose production. Upadhyay et al. (2007) isolated essential oils from *Cleome gynandra* and studied for their insecticidal, oviposition inhibitory and repellent activity against pulse beetle and concluded that these essential oils could be used in the control of storage pests and are quite safe. Bala et al. (2010) studied anticancer activity of methanolic extract of *Cleome gynandra* in swiss albino mice and showed that plant has potent dose dependent anticancer activity.

Polasa and Rukmini (1980) tested eight unconventional oils by the Ames mutagenicity assay and recorded no mutagenic activity of *Cleome viscosa* oil. Sebastian and Bhandari (1990) have carried out ethnobotanical survey from Rajasthan and reported that certain plants such as *Fumaria indica, Brassica juncea, Cleome viscosa, Portulaca oleracea, Bauhinia variegata* are used as vegetable. Khare et al. (1992) collected fifty plants for the study of their efficacy against stored grain insect pests. Four ornamental plants and two wild plants *Cleome viscosa* and *Boenninghausenia albiflora* were found naturally infested by *Lasioderma serricorne*. Maikhuri et al. (2000) described the agronomy, yield, cost-benefit analysis, uses, and ethnobotany of *Cleome viscosa* and suggested that systematic efforts must be made to promote its cultivation on a larger scale in the degraded and in marginal agricultural lands where traditional crops grow with difficulty. Devi et al. (2002) studied anti-diarrheal potential of the entire *Cleome viscosa* L. plant on rats. Bhamarapravati et al. (2003) studied gastroprotective properties of methanol extracts of *Cleome viscosa* (leaf) plants. Devi et al. (2003) studied anti-inflammatory potential of methanol extracts of *Cleome viscosa* against carrageenin, histamine and dextran induced rat paw oedema. They also studied antipyretic activity of a methanol extract of this plant on normal body temperature and yeast-induced pyrexia in albino rats. They showed that there was significant reduction in normal body temperature and yeast-provoked elevated temperature. Oladele and Abatan (2003) studied toxic effects of crude aqueous extracts of the leaves of *Cleome viscosa*, on serum biochemical parameters and histopathology in albino rats and reported that there was significant increase in the blood urea nitrogen in the rats and they concluded that the effect of *Cleome viscosa* is nephrotoxic. Parimaladevi et al. (2003) studied analgesic activity of methanol extract of *Cleome viscosa* in mice, and reported promising activity in all the tests. Vijayan et al. (2003) have investigated antifungal activity of *Cleome viscosa*. A study on *Cleome viscosa* by Williams et al. (2003) revealed the presence of secretory glandular, club-
cylinder and cylinder shaped trichomes on the leaves and stems of *C. viscosa* were extracted with hexane and the extract was evaluated for different biological activities like antibacterial, anti-fungal, insecticidal and nematicidal activity. Sudhakar *et al.* (2006) tested antimicrobial activity of ethanolic extracts of the leaves and flowers of *Cleome viscosa* against *Escherichia coli*, *Proteus vulgaris* and *Pseudomonas aeruginosa*.

Bose *et al.* (2007) have studied antimicrobial activity, analgesic, anti-inflammatory and antipyretic activity of the ethanolic extracts of *Cleome rutidosperma*.

Bellakhdar (1997) have reported that in the Sahara and Dra region, fruits and leaves, mixed with *Cleome arabica* L. sub sp. Amblyocarpa and olive oil are used as anti-inflammatory ointments. Bouriche *et al.* (2003) found that *Cleome arabica* contains higher amount of flavonoids (19%) due to which it posses high anti-inflammatory activity. The effects of *Cleome arabica* leaf extract, rutin and quercetin on soybean lipoxygenase (Lox) activity was investigated by Bouriche *et al.* (2005). It was found that the extract was beneficial for the treatment of inflammatory conditions, particularly those characterised by excessive leukotriene generation. Ismail *et al.* (2005) studied antiinflammatory property and flavanoids of *Cleome arabica* leaves and twigs.

Yaniv *et al.* (1987) have done ethnobotanical survey for the medicinal plants of Israel, 16 species were found to be used for hypoglycaemic treatments, *Cleome drosarifolia* is one of those. Hegazy and Fadl-Allah (1995) studied the effect of *Cleome drosarifolia* shoot extract on its seed germination and seedling growth. *Cleome drosarifolia* was found autotoxic. A total of 20 fungal species belonging to 10 genera were found by Badran and Aly (1995) to be associated with all stages of *Culex pipiens*. The water extract of both *Artemesia cina* and *Cleome drosarifolia* showed an inhibitory effect on the protein content and growth of some selected isolates. Hegazy and Fadl-Allah (1995) examined the effect of different extracts of *Cleome drosarifolia* on its seed germination and seedling growth, and concluded that *Cleome drosarifolia* is autotoxic. They tested allelopathic effects of *Cleome drosarifolia* on *Penicillium chrysogenum* and *P. funiculosum* and found that these fungi are most sensitive. Badri *et al.* (1996) have studied accumulation of metals in *Cleome drosarifolia*. Khafagi (1998) studied anthelminthic and antibacterial activity of ethanolic extracts of twelve plant species including *Cleome drosarifolia* (Forssk.) Del. against six bacterial strains.
Shahina et al. (1993) reported that *Cleome rupicola* extract can be applied as eye-drops. Hawley (1930) prepared black carbon paint from *Cleome*. Saboor et al. (1984) have tested *Cleome dolichostyla* seed oil extract for iodine number, saponification number, Hehner value, Reichert-Meissl number and refractive index and reported its potential as an edible oil for human. Shackleton (2003) examined use and commercial value of wild edible herbs in South Africa which include *Amaranthus, Bidens, Chenopodium, Cleome, Corchorus* and *Momordica*. Juan and Gabriele (2004) Studied herbal mixtures in the traditional medicine of Eastern Cuba and created 199 formulae by using one hundred seventy plant species including *Cleome* species. Claudia et al. (2006) compared methanolic extracts of *Cleome rosea*, collected from natural habitat and from *in vitro* propagated plants. They also analysed different *in vitro* biological assays and reported that *C. rosea* presents medicinal potential and that the acclimatization process reduces the plant toxicity both to plasmid DNA and to J774 cells.

**PATHOLOGY**

Species like *Cleome spinosa* are susceptible to different pathogens like *Puccinia vexans, P. tosta, P. subnitens*, tobacco budworm, *Peronospora parasitica*, cabbage white butterfly, *Erysiphe cruciferarum, Aphis gossypii* Glover and *Myzus persicae* aphids (Arthur, 1905a,1905b; Bates, 1905; Olive, 1948; Leonard, 1967; Wendell et al., 1974; Alam, 1992 and Ale and Feige, 2000). *Puccinia subnitens* also grows on *Cleome serrulata* (Bates 1905). Cabbage white butterfly insect breeds on weeds like *Cleome viscosa* and *Cleome gynandra* and parasite complex of cabbage budworm is richer and more consistent on *Cleome* species (Alam, 1992). Benrey et al. (1997) investigated the influence of four host plant species, including *Cleome spinosa* (spider flower), on two components of the host selection process in *Cotesia glomerata* (L.), namely, attraction and host acceptance and concluded that phytochemistry mediates host selection more by influencing parasitoid attraction than it does by affecting host acceptance.

Ellis and Halsted (1890) and Kellerman (1906) reported new fungal species *Cercospora cleomis* on *Cleome pungens*, *Cercospora conspicua* on *Cleome gynandra* and *Eeidium cleomis* on *Cleome integrifolia* (Ellis and Anderson, 1891).

Raman and Sanjayan (1984) studied the host plant and pathogen relationships in terms of the comparative growth rate, survival percentage, reproductive efficiency and
population dynamics and indicated that the most preferred host plant for mirid, *Cyrtopeltis tenuis* are *Lycopersicon esculentum* Mill. (Solanaceae), followed by *Luffia cylindrica* Roxb. (Cucurbitaceae), *Cleome viscosa* L. and *Gynandropsis pentaphylla* DC. Different *Cleome* species are recorded as host plant for many pathogens such as *Cleome gynandra* as host plant for *Liriomyza hawaiiensis* (Frick, 1953); *Cleome graveolens* Raf. for crown gall disease (Marcel and Jozef, 1976); *Cleome viscosa* for powdery mildew (Reddy and Reddi, 1980); *Cleome viscosa, C. spinosa* for PRSV melon viruse and *C. viscosa* for WMV-2 and ZYMV melon viruses (Sanchez et al., 1998) and also for *Albugo cruciferarum*, the white rust of mustard (Khunti et al., 2000). Zhang and Wang (1981) reported *Albugo capparidis* on *Cleome gynandra* L. and *C. viscosa* L.

*Cleome rutidosperma* is infected by *Appias libythea* (Ooi, 2000) and cabbage webworm (Sivapragasam and Chua, 1997). The egg to adult development of diamondback moth, *Plutella xylostella* (L.) was found fastest on *Cleome hassleriana* (Sarfraz et al. 2009). Getachew et al. (2005) reported unwanted and health problematic effect due to *Cleome gallensis* plants.

Mamula (1976) worked on of transmission of belladonna mottle virus (BMV) to *Cleome spinosa* plants. Bohart and Smith (1978) studied plant insect interaction between *Ammoplanops* and *Cleome* species. Field studies were conducted by Mehra et al. (1987) on weed control in irrigated groundnut and recorded that Fluchloralin, pendimethalin and oxadiazon herbicide treatments were found effective against, *Cleome viscosa* and *Diodia teres*. Nyambo (1990) studied insect pest of cotton in Western Tanzania and investigated the role of natural enemies in regulating the larvae populations of the pest in the mixed cropping system using *Cleome* sp. They observed that the diseases (viral and bacterial) and parasitism were identified as important mortality factors of the larvae populations but neither prevented the pest population from causing economic damage on the crops.

From the literature, thus it appears that there is very scanty and scattered work on the genus *Cleome* with respect to anatomy and physiology. The comparative studies in anatomy, physiology and biochemistry will help to understand and strengthen the knowledge of interrelationship among the *Cleome* species. In the present investigation, therefore, an attempt has been made to study the detailed anatomy of *Cleome* species found in the region of Kolhapur district and adjoining areas. An attempt has also been made to study their
physiology. Biochemical analysis has also been carried out in the species. The present attempt is to show that the study will help to understand the interrelationship among the species with respect to their anatomy, physiology and biochemistry. The study may also provide some guidelines for understanding the nutritional value of the *Cleome* species.