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Paradermal studies on the stomata of some species of Asteraceae

Harpreet Kaur and Avinash Kaur Nagpal✉

Department of Botanical and Environmental Sciences, Guru Nanak Dev University, Amritsar – 143005, Punjab, India
✉Corresponding author: avnagpal@yahoo.co.in

ऐस्टरेसी की कुछ जातियों के वातरंध्र पर आधारित (पैराडर्मल) अध्ययन

हरप्रीत कौर, अविनाश कौर नागपाल

सारांश

वातरंध्र (स्टोमैटा) एक विशेष प्रकार की संरचनायें हैं, जो पौधे और पर्यावरण के मध्य गैसों के (कार्बनडाइक्साइड और ऑक्सिजन) आदान प्रदान का कार्य कर दो महत्वपूर्ण शारीरिकीय कार्यों –प्रकाश संश्लेषण एवं श्वसन का निर्वहन करती हैं। वातरंध्रों की संरचना पादप वर्गिकी में पौधे की पहचान के अभिनिर्धारण में भी महत्वपूर्ण है। प्रस्तुत शोध पत्र हल्के सूक्ष्मदर्शी और स्कैनिंग इलैक्ट्रॉन माइक्रोस्कोप का उपयोग कर ऐस्टरेसी कुल की 15 जातियों के वातरंध्र पर के अंत:सतही (पैराडर्मल) अध्ययन से सम्बन्धित है। अध्ययन से ज्ञात होता है कि वातरंध्र संरचना एवं पत्ते के ऊपरी (एडेक्सियल) एवं निचली सतहों (एबेक्सियल) पर पाये जाने स्टोमैटा की संख्या में भिन्नता है । इस अध्ययन से दो प्रकार के स्टोमैटा जैसे एनोमोसाइटिक (अनियमित कोशिका) एवं एनियोसाइटिक (असमान कोशिका) अवलोकित किये गये हैं। ऐस्टरेसी कुल की विभिन्न जातियों के पत्तों पर किये गये अध्ययन से पता चलता है कि इनके वातरंध्र का घनत्व निचली सतह पर 41.519 मि.मि.$^{-2}$ (*गिलार्डिया पुलचेल्ला*) से 276.166^{-2} मि.मि. (*हेलेंथस एन्नूस*) के रेंज में एवं ऊपरी सतह पर 23.90 मि.मि.$^{-2}$(*गिलारडिया पुलचेल्ला*) से 225.83मि.मी.$^{-2}$ (*वेलडिलिया ट्राइलोबाटा*) तक है। 13 जातियो के स्टोमैटा मध्यम आकार के हैं और दो जातियों *गिलार्डिया पुलचेल्ला* एवं *जिनिया मल्टिफेरा* के स्टोमैटा बृहताकार के हैं.

ABSTRACT

Stomata are specialized structures responsible for exchange of gases i.e. CO_2 and O_2 between plants and the environment thereby performs two important physiological functions, *viz*., photosynthesis and respiration. The structure of stomata is considered as important taxonomic tool for identification of plants. The present paper deals with the paradermal studies on the stomata of 15 species of family Asterecece done through light microscope and scanning electron microscope. The study reveals a considerable difference in the structures and number of stomata found on the adaxial and abaxial surfaces of the leaf. Two types of stomatal types *viz*. anomocytic (irregular celled) and anisocytic (unequal celled) were observed in the present study. Stomatal density was found to be ranging from 41.519 mm^{-2} (*Gillardia pulchella*) to 276.166 mm^{-2} (*Helianthus annuus*) on the abaxial surface of leaves while 23.90 mm^{-2} (*Gillardia pulchella*) to 225.83 mm-*2* (*Wedelia trilobata*) on the adaxial surface of leaves of selected species of Asteraceae. Stomata of 13 species were of medium size and only two species *Gillardia pulchella* and *Zinnia multiflora* showed stomata to be of large size.

Keywords: Paradermal Study, Taxonomy, Asteraceae, Stomata, Stomatal density

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INTRODUCTION

The taxonomic relevance of foliar epidermal structures like stomata and trichomes has been well documented (Adedeji and Illoh, 2004; Adedeji, 2004; Celka & al., 2006; Dehgan, 1980; Jayeola and Adenegan, 2001; Parveen & al., 2000; Yasmin & al., 2009; Zou & al., 2008). The term stoma (plural stomata), is derived from Greek, which means 'opening or mouth' and includes both the guard cells and the pore between them. Stomata are concerned with exchange of gases (CO_2 and O_2 between plants and the environment), which is important for two most important life processes- photosynthesis and respiration. They also play a crucial role in transpiration due to their involvement in loss of excess water absorbed from the soil. Since photosynthesis is considered as a major factor for determining crop yield, the study of stomata becomes important for studies related to factors affecting crop yield (Rahman, 2011).

The family Asteraceae is represented by more than 30,000 and over 1100 genera. In India, the family is represented by 167 genera and *ca* 900 species (http://eflora-india.nic.in/). Majority of the species are herbaceous, but other forms like shrubs, succulents, lianas, epiphytes and rarely trees are also found (Bremer, 1994; Dutta, 1974; Funk & al., 2005; Mbagwu & al., 2006).

Many plants of the family are economically important, and are also used as ornamentals (*Aster amellus*, *Chrysanthemum indicum*, *Cosmos bipinnatus*, *Dahlia pinnata*, *Helianthus annuus*, *Tagetes erecta*, *Zinnia americana* etc.), in medicines (*Mikania glomerata*, *Porophyllum ruderale* and *Vernonia condensata* etc.) or vegetables (*Crassocephalum crepidioides*, *Helianthus annuus, Lactuca sativa* (lettuce), *Launaea taraxacifolia, Vernonia amygdalina* (bitter leaf) while others are weeds (*Chromolaena odorata*, *Tridax procumbens*, *Ageratum conyzoides*). Since Asteraceae is the largest family of flowering plants and structure of stomata is considered as an important aid in identification of plants, the present paper involves Light Microscopic and Scanning Electron Microscopic studies on the stomata of 15 species of Asteraceae collected from Amritsar, Punjab, India.

MATERIALS AND METHODS

The different area of Amritsar was surveyed and young leaves of 15 plant species of the family Asteraceae were collected. These areas were chosen as they represent most of the plant diversity of Amritsar. Table 1 gives the tribe wise list of plant species covered in the present study. The herbarium specimens of these plant species were prepared and submitted to the herbarium of Department of Botanical and Environmental Sciences, Guru Nanak Dev University, Amritsar (GNDUH) and Botanical Survey of India, Northern Regional Centre, Dehra Dun (BSD) (www.bsi.gov.in). Leaves were fixed in Formalin- Acetic acid- Alcohol (FAA) for 24 hrs and subsequently stored in 70% alcohol. The epidermal peelings from both the adaxial and abaxial surfaces were separately stripped off smoothly either with the help of needles and forceps from the middle portion of the leaf or by impression technique (Hilu & Randall, 1984). The epidermal peelings were stained in 1% aqueous Safranin and mounted in Glycerine for microscopic study. For impression technique, a thin layer of transparent nail polish was directly applied to the surface of leaf. After drying, the impression left on the polish layer produced detailed image of the epidermis. The prepared slides were studied under light microscope (Olympus microscope MLXi Freedom Microscope) fitted with Olympus SLR digital camera. The ocular micrometer calibrated with the stage micrometer was used to study different parameters. The parameters studied were the type and frequency of stomatal complex on each epidermis, density (number of stomata per square millimeter), stomatal index (number of stomata per square millimeter/ number of stomata + number of epidermal cells per square millimeter X 100 (Dilcher, 1974), size of stomata (length/width of stomata (stomatal pore + guard cells) average of 10 readings and length of stomatal pore (average of 10 readings). The statistical evaluation of the stomata included mean and standard error. For scanning electron microscopy, a piece of dried leaf was mounted on a metallic stub with the help of double adhesive tape and coated with silver and examined under SEM (Carl Zeiss EVO LS-10). Terminologies of the stomatal complex types used in this study are those of Dilcher (1974) and Metcalfe and Chalk (1950).

RESULT AND DISCUSSION

Stomatal characteristics such as type of stomatal complex, stomatal density and stomatal index of 15 species of Asteraceae are given in Table 2. Stomata are lens shaped present on both surfaces of the leaves

Table 1: Details of plant species collected.

Tribe	Sub Tribe	Plant Name	Collection site	Date of collection	Voucher No.
Astereae		*Erigeron bonariensis* L.	Namak Mandi, Amritsar	23/03/2012	GNDUH 6915, GNDUH 6916, GNDUH 6917, BSD 115236
Cichorieae	Lactuceae	*Launaea residifolia* L.	Mall road, Amritsar	03/05/2012	GNDUH 6849, GNDUH 6850, BSD 115226
		Sonchus oleraceus L.	Maquboolpura road, Amritsar	05/03/2012	GNDUH 6909, GNDUH 6910
		Sonchus wightianus DC.	Khalsa College of Veterinary and Animal Sciences	20/09/2013	GNDUH 6995
Heliantheae		*Cosmos bipinnatus* Cav.	Botanical Garden, GNDU, Amritsar	12/04/2013	GNDUH 6930, GNDUH 6931, GNDUH 6932, BSD 115238
		Eclipta alba (L.) Hassk.	Botanical Garden, GNDU, Amritsar	02/08/2011	GNDUH 6883, GNDUH 6884, GNDUH 6885, GNDUH 6886, GNDUH 6887, BSD 115231
		Gillardia pulchella L.	Goll Bagh, Amritsar	14/07/2012	GNDUH 6836, GNDUH 6837, BSD 115225
		Helianthus annuus L.	Guru Nanak Stadium, Amritsar	04/06/2013	GNDUH 6935, GNDUH 6936, GNDUH 6937, GNDUH 6938, GNDUH 6939, GNDUH 6940, GNDUH 6941, BSD115239
		Parthenium hysterophorus L.	Namak Mandi, Amritsar	08/06/2011	GNDUH 6877, GNDUH 6878, GNDUH 6879, BSD 115263
		Verbescinia enceliodes (Cav.) Benth. & Hooker f. ex Gray	Goll Bagh, Amritsar	14/072012	GNDUH 6975
		Wedelia trilobata (L.) A.S. Hitchc.	Company Bagh, Amritsar	10/08/2013	GNDUH 6988
		Zinnia multiflora L.	Guru Nanak Stadium, Amritsar	04/06/2013	GNDUH 6933, GNDUH 6934, BSD 115246
Inuleae	Gnaphaleae	*Gnaphalium purpureum* L.	Circular Road, Amritsar	09/11/2011	GNDUH 6891, GNDUH 6892, GNDUH 6893, GNDUH 6894, BSD 115233
	Plucheineae	*Blumea mollis* D. Don.	Kotatma ram, Amritsar	26/02/2013	GNDUH 6925, GNDUH 6926, GNDUH 6927, BSD 115237
Tageteae		*Tagetes erecta* L.	Guru Nanak Stadium, Amritsar	04/06/2013	GNDUH 6981, GNDUH 6982

(GNDUH - Herbarium of Department of Botanical & Environmental Sciences, Guru Nanak Dev University, Amritsar; BSD - Botanical Survey of India, Northern Regional Centre, Dehra Dun)

Table 2: Stomatal characteristics in studied species of Asteraceae

Tribe	Sub Tribe	Plant Name	Leaf Surface	Stomatal complex		Stomatal density (mm^{-2})	Stomatal index (SI)
				Type	Frequency (%)		
Astereae		*Erigeron bonariensis* L.	Abaxial	Anomocytic	100.00	165.44	20.34%
			Adaxial	Anomocytic	100.00	121.41	20.38%
Cichorieae	Lactuceae	*Launaea residifolia* L.	Abaxial	Anomocytic Anisocytic	66.43 33.57	262.32	30.82%
			Adaxial	Anomocytic	100.00	178.65	28.60%
		Sonchus oleraceus L.	Abaxial	Anomocytic	100.00	130.21	35.20%
			Adaxial	Anomocytic	100.00	56.61	19.14%
		Sonchus wightianus DC.	Abaxial	Anomocytic Anisocytic	78.08 21.91	137.76	10.49%
			Adaxial	Anomocytic	100.00	69.82	7.97%
Heliantheae		*Cosmos bipinnatus* Cav.	Abaxial	Anomocytic Anisocytic	61.72 38.27	211.95	34%
			Adaxial	Anomocytic	100.00	104.42	19.85%
		Eclipta alba (L.) Hassk.	Abaxial	Anomocytic	100.00	256.65	20.18%
			Adaxial	Anisocytic	100.00	188.8	20.12%
		Gillardia pulchella L.	Abaxial	Anomocytic	100.00	41.519	17.88%
			Adaxial	Anomocytic	100.00	23.90	13.33%
		Helianthus annuus L.	Abaxial	Anomocytic	100.00	276.166	33.16%
			Adaxial	Anisocytic	100.00	195.01	32.63%
		Parthenium hysterophorus L.	Abaxial	Anomocytic	100.00	171.11	24.28%
			Adaxial	Anisocytic	100.00	139.65	23.36%
		Verbescinia enceliodes (Cav.) Bentham & Hooker fil. ex Gray	Abaxial	Anomocytic	100.00	110.71	26.07%
			Adaxial	Anomocytic	100.00	58.50	23.25%
		Wedelia trilobata (L.) A.S. Hitchc.	Abaxial	Anisocytic	100.00	269.87	23.02%
			Adaxial	Anomocytic	100.00	225.83	20.71%
		Zinnia multiflora L.	Abaxial	Anomocytic Anisocytic	77.19 22.81	116.37	22.28%
			Adaxial	Anomocytic Anisocytic	83.33 16.66	135.87	24.36%
Inuleae	Gnaphaleae	*Gnaphalium purpureum* L.	Abaxial	Anomocytic Anisocytic	84.15 15.84	127.07	34.94%
			Adaxial	Anomocytic	100.00	42.96	13.27%
	Plucheineae	*Blumea mollis* D. Don.	Abaxial	Anomocytic	100.00	114.49	24.86%
			Adaxial	Anisocytic	100.00	123.29	25%
Tageteae		*Tagetes erecta* L.	Abaxial	Anomocytic	100.00	254.14	21.08%
			Adaxial	Anomocytic	100.00	171.73	20.00%

(amphistomatic), often more numerous on abaxial epidermis than on adaxial. Guard cells are kidney shaped. Plates I-XV, shows Light and Scanning Electron micrographs of stomata of different species studied. Literature survey on stomatal studies of family Asteraceae revealed that among 15 different species investigated in the present study, stomatal study of only 5 species namely *Eclipta alba, Helianthus annuus, Perthenium hysterophorus, Wedelia trilobata* and *Launaea residifolia* has been reported earlier (Perveen & al., 2007; Mahbubur Rahman & al., 2013; Mahbubur Rahman, 2013; Shaheen & al., 2012). Two types of stomatal complexes viz. Anomocytic and anisocytic were observed in the present study. According to classification of Metcalfe and Chalk (1950) and Dilcher (1974), Anisocytic stoma is a stoma completely surrounded by only three subsidiary cells variable in position, shape and size with one of the subsidiary cells distinctly small and Anomocytic stoma is stoma surrounded by four or more subsidiary cells, variable in position, shape and size.

The study reveals difference in type of stomata and number of stomata between adaxial and abaxial surfaces of the leaf and different species studied. Among the 15 species studied stomatal complexes of 5 species, namely *Erigeron bonariensis* L., *Tagetes erecta* L., *Gillardia pulchella* L., *Verbesina enceliodes* (Cav.) Bentham & Hooker f. ex Gray and *Launaea residifolia* L. were found to be only one type i.e., anomocytic in both abaxial and adaxial leaf surfaces whereas leaves of 10 other species (Table 2) showed both anomocytic and anisocytic stomatal complexes.

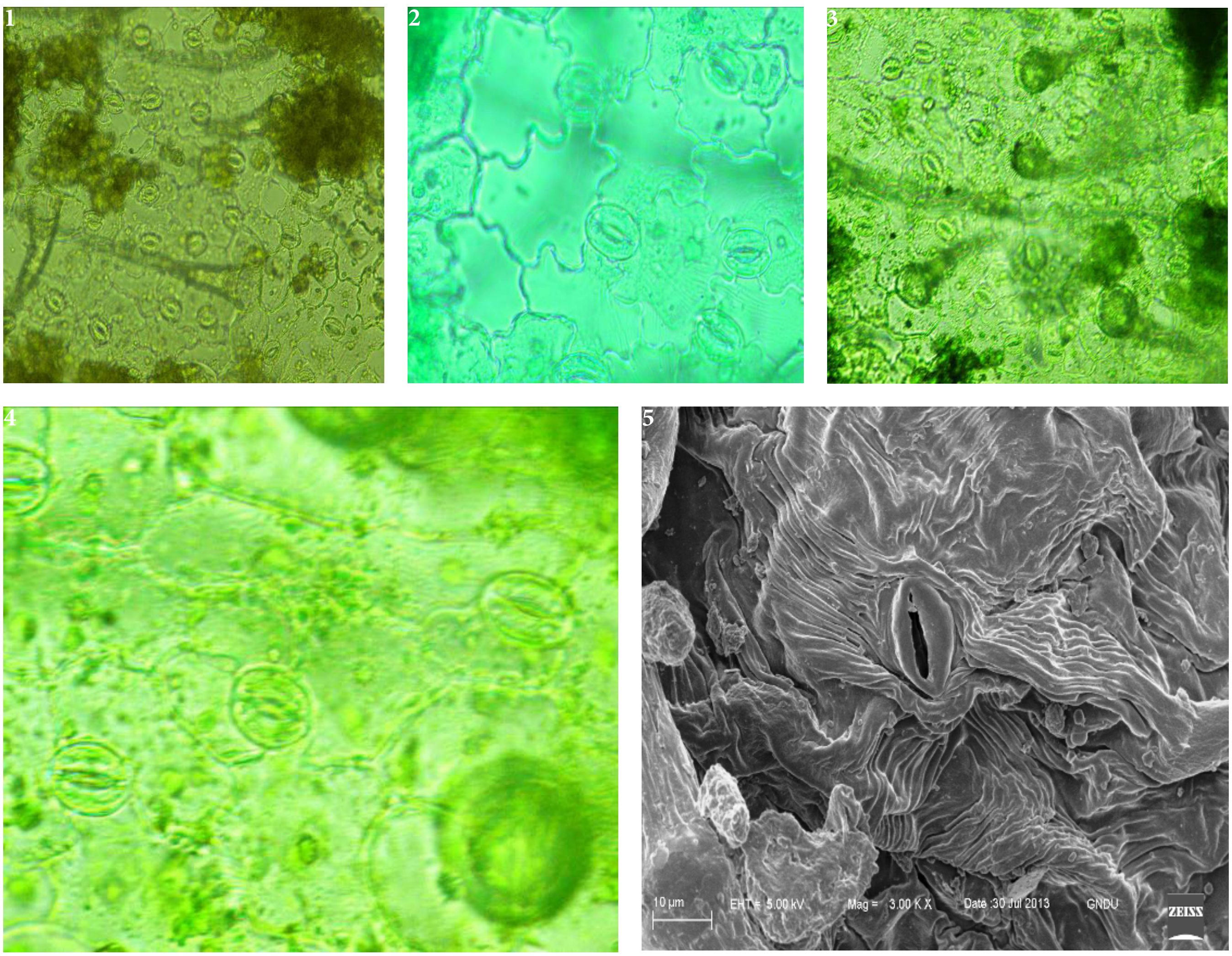

Plate -I. Light (1-4) and Scanning Electron Micrographs (5) of stomata of *Erigeron bonariensis* L.; **1, 2** - abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5** - abaxial surface (3.00 Kx, scale bar- 10µm).

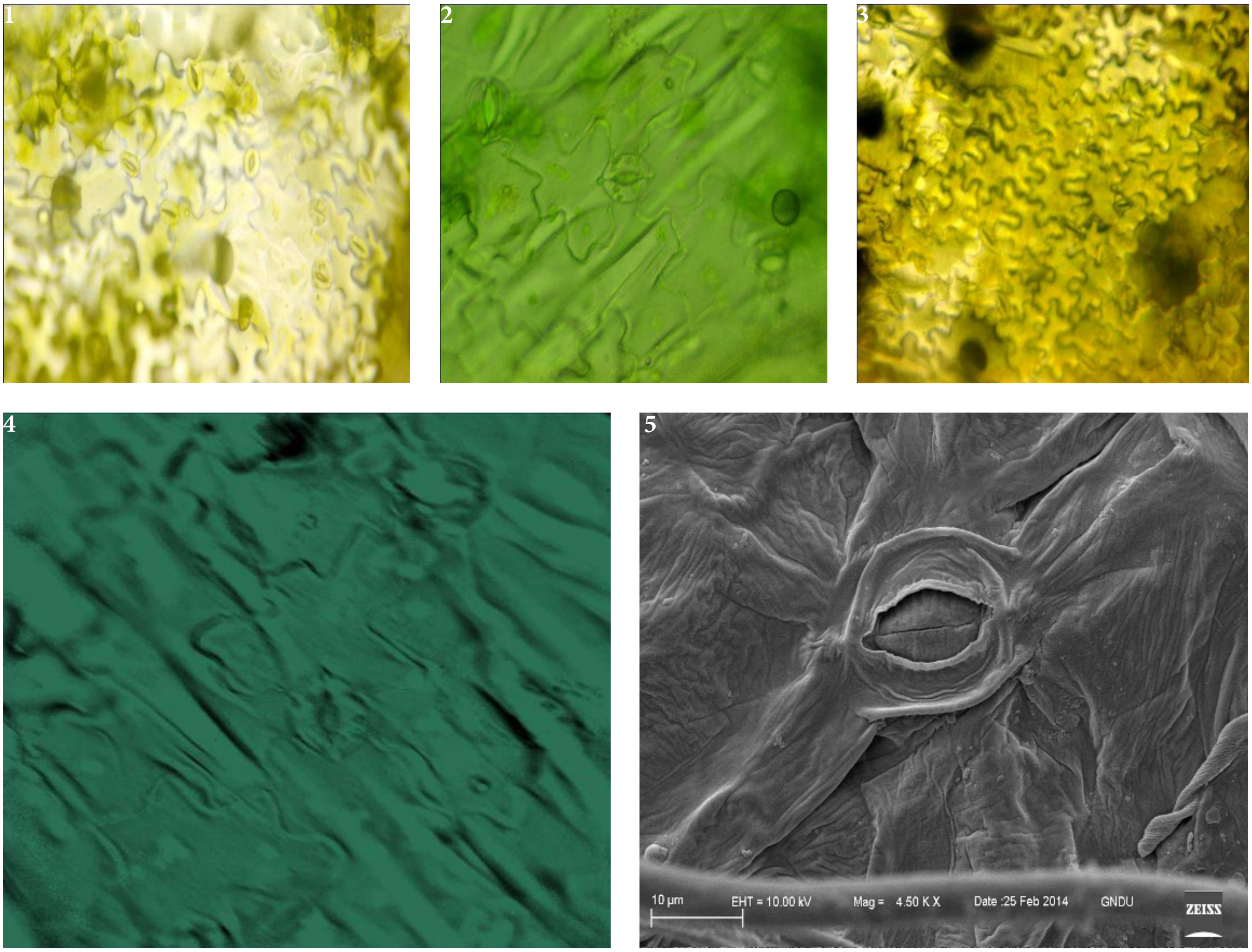

Plate -II. Light (1 - 4) and Scanning Electron Micrographs (5) of stomata of *Gnaphalium purpureum* L.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5** - abaxial surface (4.50 Kx, scale bar- 10µm).

In *Gnaphalium purpureum*, *Cosmos bipinnatus*, *Zinnia multiflora*, *Launaea residifolia*, and *Sonchus wightianus,* the abaxial leaf surface was found to be possess both anomocytic and anisocytic stomatal complexes whereas frequency of anomocytic complexes was found to be more than that of anisocytic complexes. The adaxial leaf surfaces of these species were found to possess only anomocytic stomatal complexes except *Zinnia multiflora* where anisocytic stomata, though in low frequency, were also found on the adaxial surface.

In *Eclipta alba*, *Helianthus annuus*, *Parthenium hysterophorus* and *Blumea mollis*, abaxial leaf surfaces possessed only anomocytic stomatal complexes whereas adaxial surfaces displayed anisocytic complexes. Our results on type of stomatal complexes of *Eclipta alba*, *Helianthus annuus*, *Parthenium hysterophorus* and *Wedelia trilobata* are in conformity with an earlier study by Mahbubur Rahman *et al*. (2013) who also reported two types of stomatal complexes (Anomocytic and Anisocytic) in these species.

Stomatal density range from 41.519 mm^{-2} (*Gillardia pulchella* to 276.166 mm^{-2} *Helianthus annuus*) on the abaxial surface of leaves and 23.90 mm^{-2} (*Gillardia pulchella*) to 225.83 mm^{-2} (*Wedelia trilobata*) on adaxial surface of leaves of different species studied. Stomatal density was found to be more on the abaxial surface than on the adaxial surface in all species except *Blumea mollis* and *Zinnia multiflora*. Stomatal density has been used as one of the diagnostic features for distinguishing different species (Noggle and Fritz, 1976; Okeke, 2004).

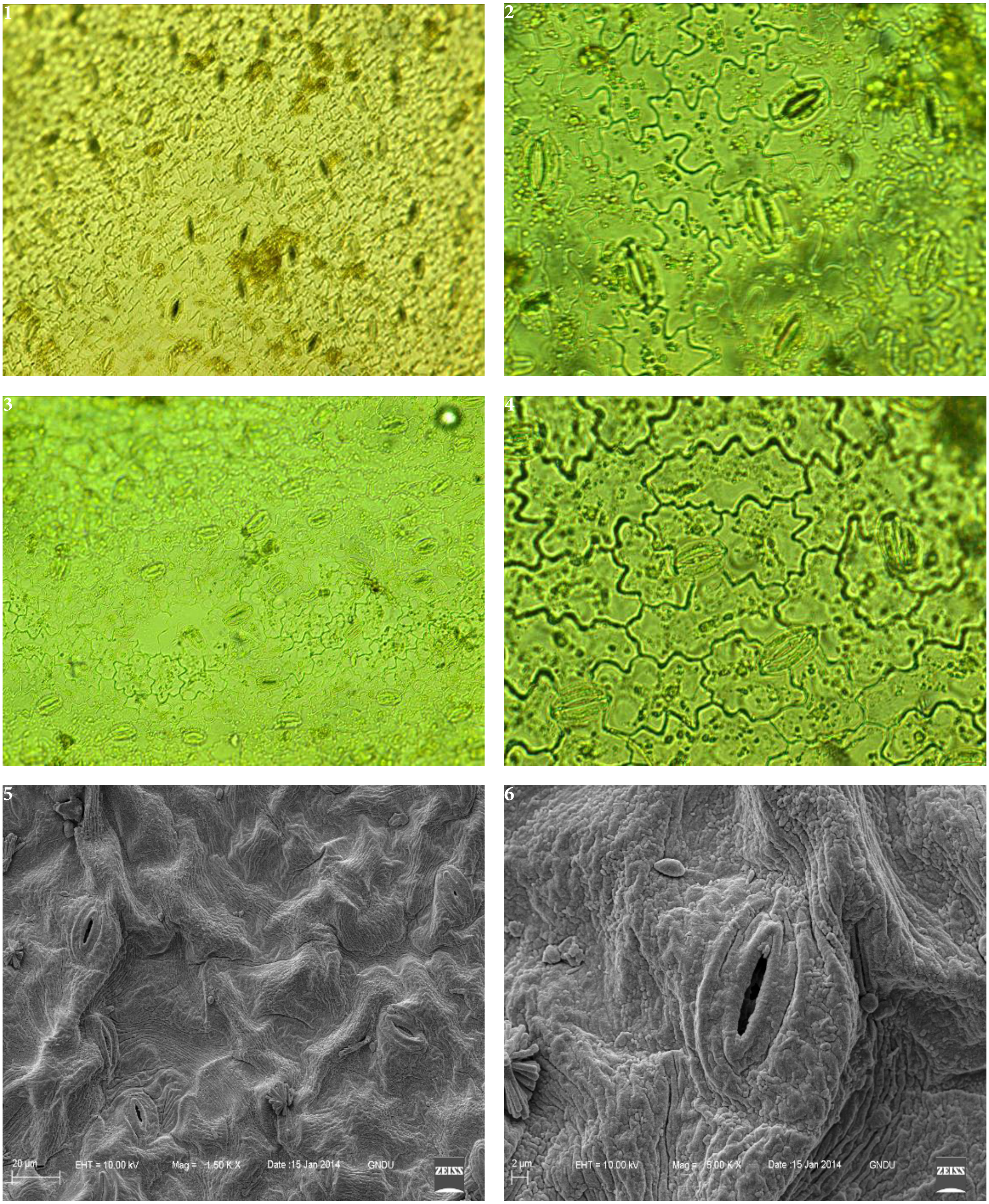

Plate -III. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Tagetes erecta* L.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (1.50 Kx, 5.00 Kx, scale bar- 20µm, 2 µm).

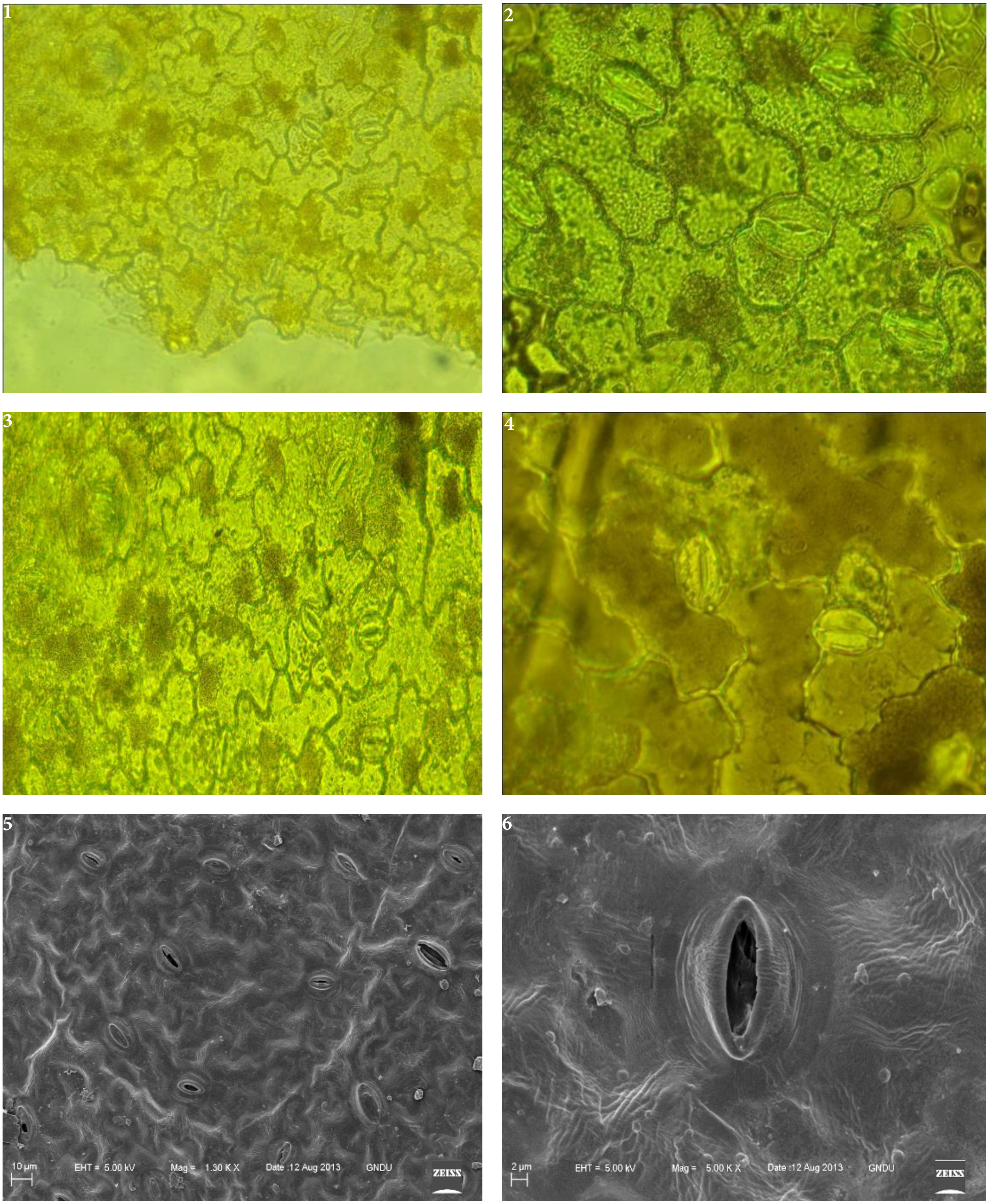

Plate -IV. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Cosmos bipinnatus* Cav.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (1.30 Kx, 5.00 Kx, scale bar- 10µm, 2 µm).

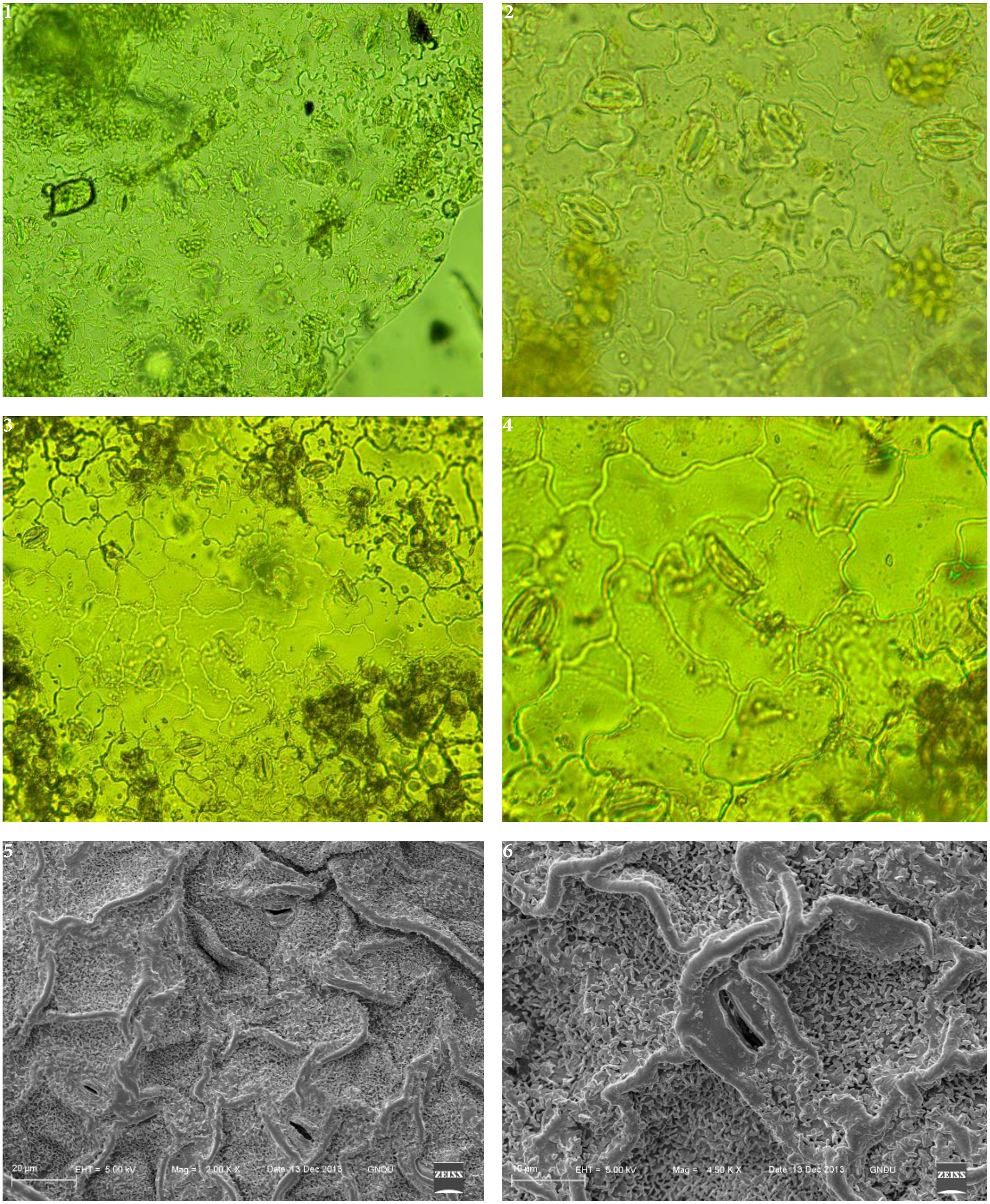

Plate -V. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Eclipta alba* (L.) Hassk.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (2.00 Kx, 4.50 Kx, scale bar- 20µm, 10 µm).

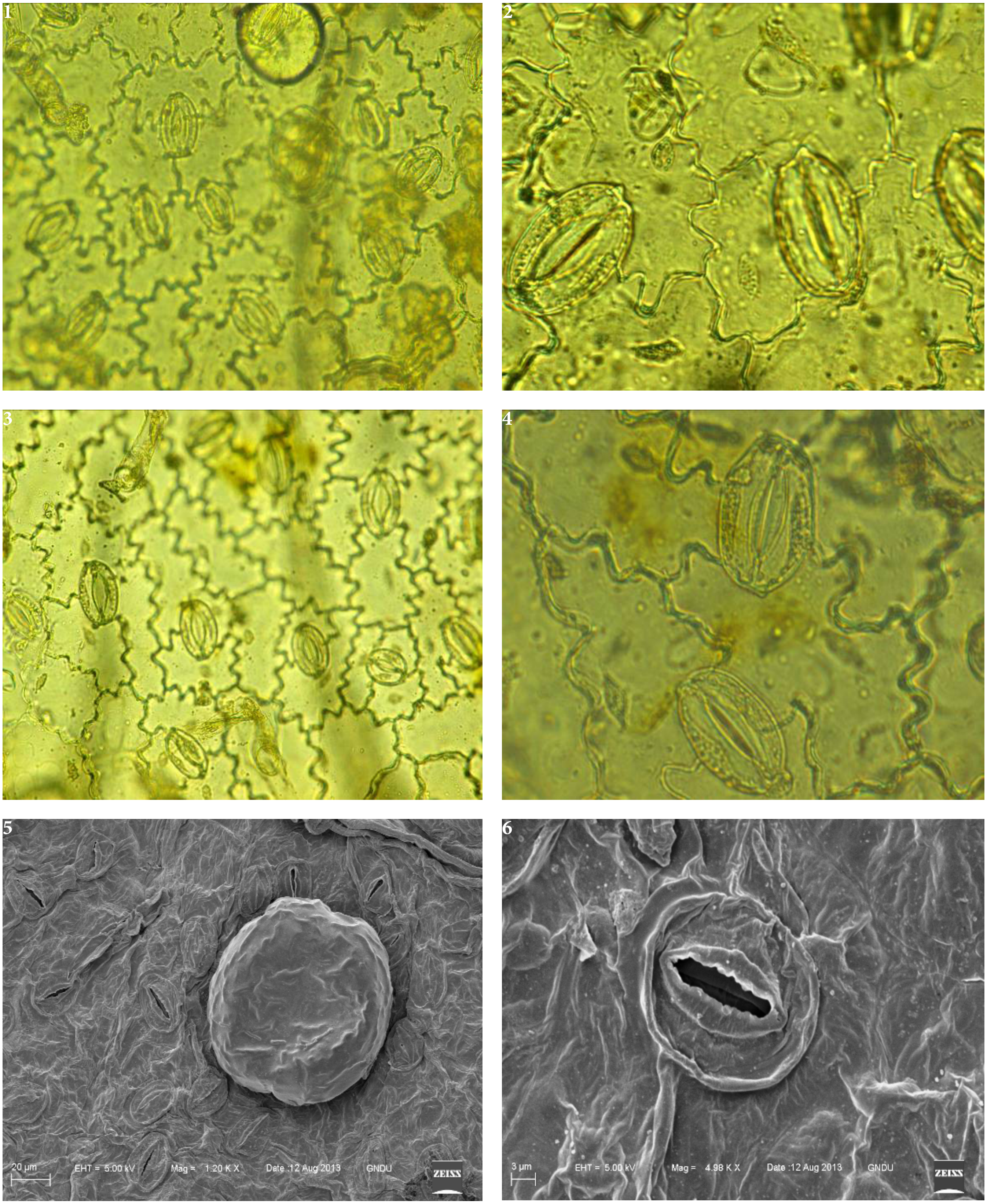

Plate -VI. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Gillardia pulchella* L.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (1.20 Kx, 4.98 Kx, scale bar- 20µm, 3 µm).

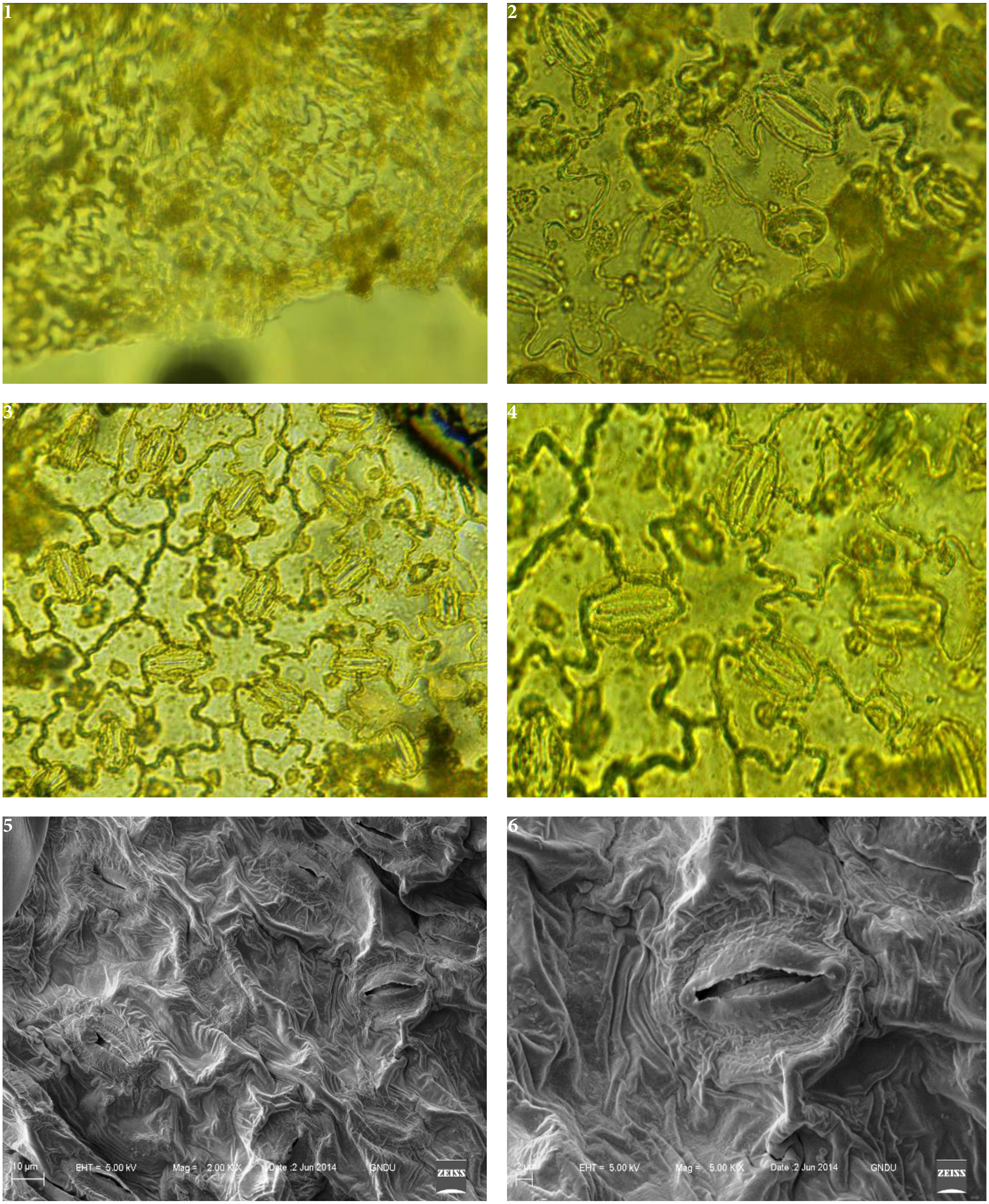

Plate -VII. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Helianthus annuus* L.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (1.20 Kx, 4.98 Kx, scale bar- 20μm, 3 μm)

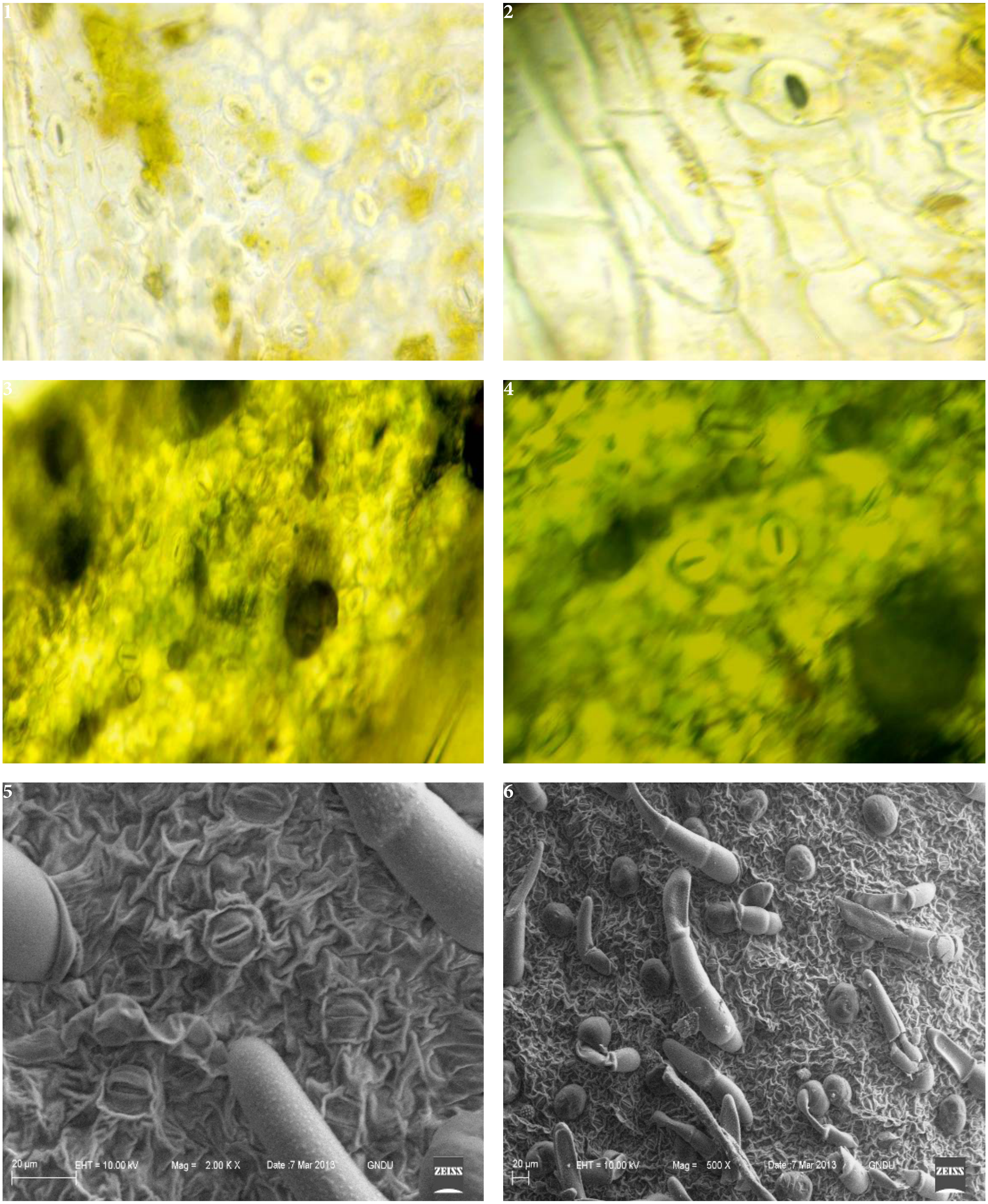

Plate -VIII. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Parthenium hysterophorus* L.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (2.00 Kx, 500 x, scale bar- 20µm, 20 µm).

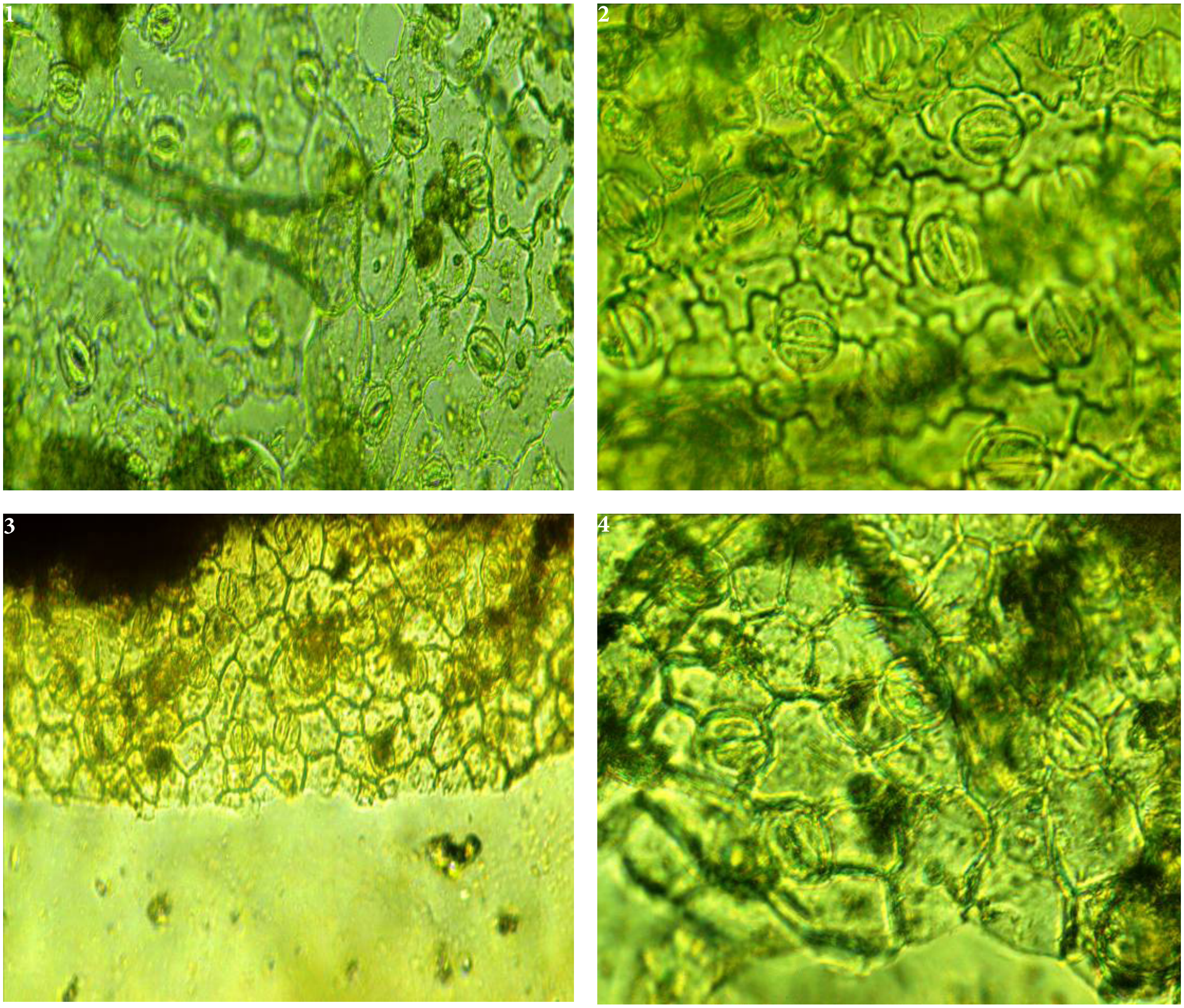

Plate -IX. Light (1 - 4) Micrographs of stomata of *Verbescinia enceliodes* (Cav.) Bentham & Hooker fil. ex Gray.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x).

Stomatal index is considered as one of the reliable taxonomic characters because it is independent of the changes in size of epidermal cells brought about by environmental factors (Metcalfe and Chalk, 1988). On abaxial surfaces of leaves of different species studied, highest stomatal index was noticed in *Sonchus oleraceae* (35.20%) and lowest in *Sonchus wightianus* (10.49%) while on adaxial surfaces highest was found in of leaves *Helianthus annuus* (32.63%) and lowest in *Sonchus wightianus* (7.97%). Stomatal index can also aid in distinguishing species. It was found that stomatal index has low value on adaxial surface as compared to abaxial surface. High value of stomatal index is indicative of high transpiration rate, metabolism and high rate of absorption of minerals and water. Species with low stomatal index indicate that they grow in CO_2 rich environment (mostly along road sides) and those with high value indicate they grow in environment with low air pollution or CO_2 concentration (Munir & al., 2011).

Table 3 gives the measurements of stomata of Asteraceae species studied. The stomatal size (stomatal pore + guard cells) ranged from 17.94 × 15.33 µm (Eclipta alba) to 52.72 × 31.46 µm (*Zinnia multiflora*) on abaxial surfaces of leaves and 20.84 × 14.35 µm (*Tagetes erecta*) to 53.54 × 36.86 µm (*Zinnia multiflora*)

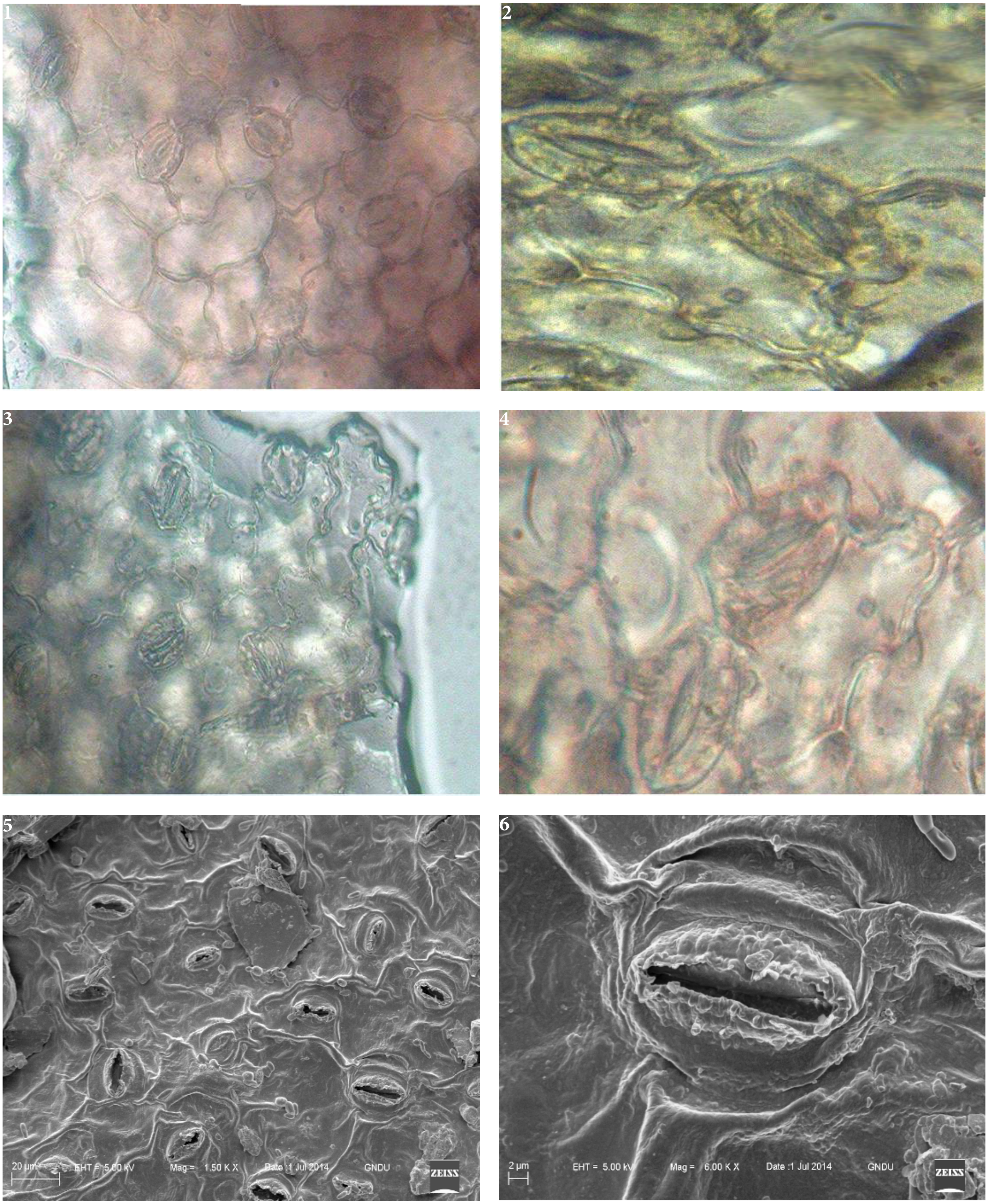

Plate -X. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Wedelia trilobata* (L.) A.S. Hitchc.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (1.50Kx, 6.00Kx, scale bar- 20µm, 2 µm).

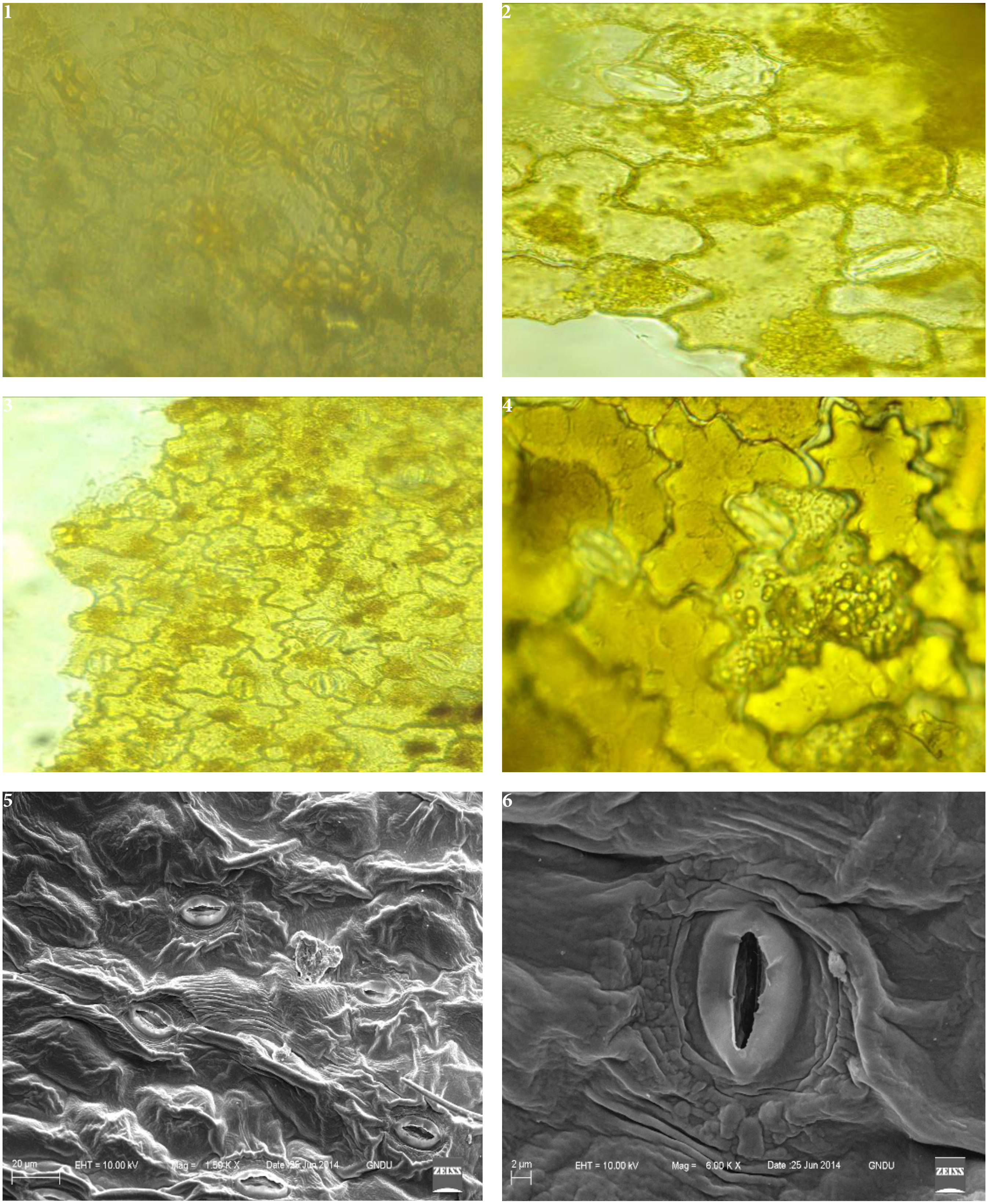

Plate -XI. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Zinnia multiflora* L.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (1.50 Kx, 6.00kx, scale bar- 20µm, 2 µm).

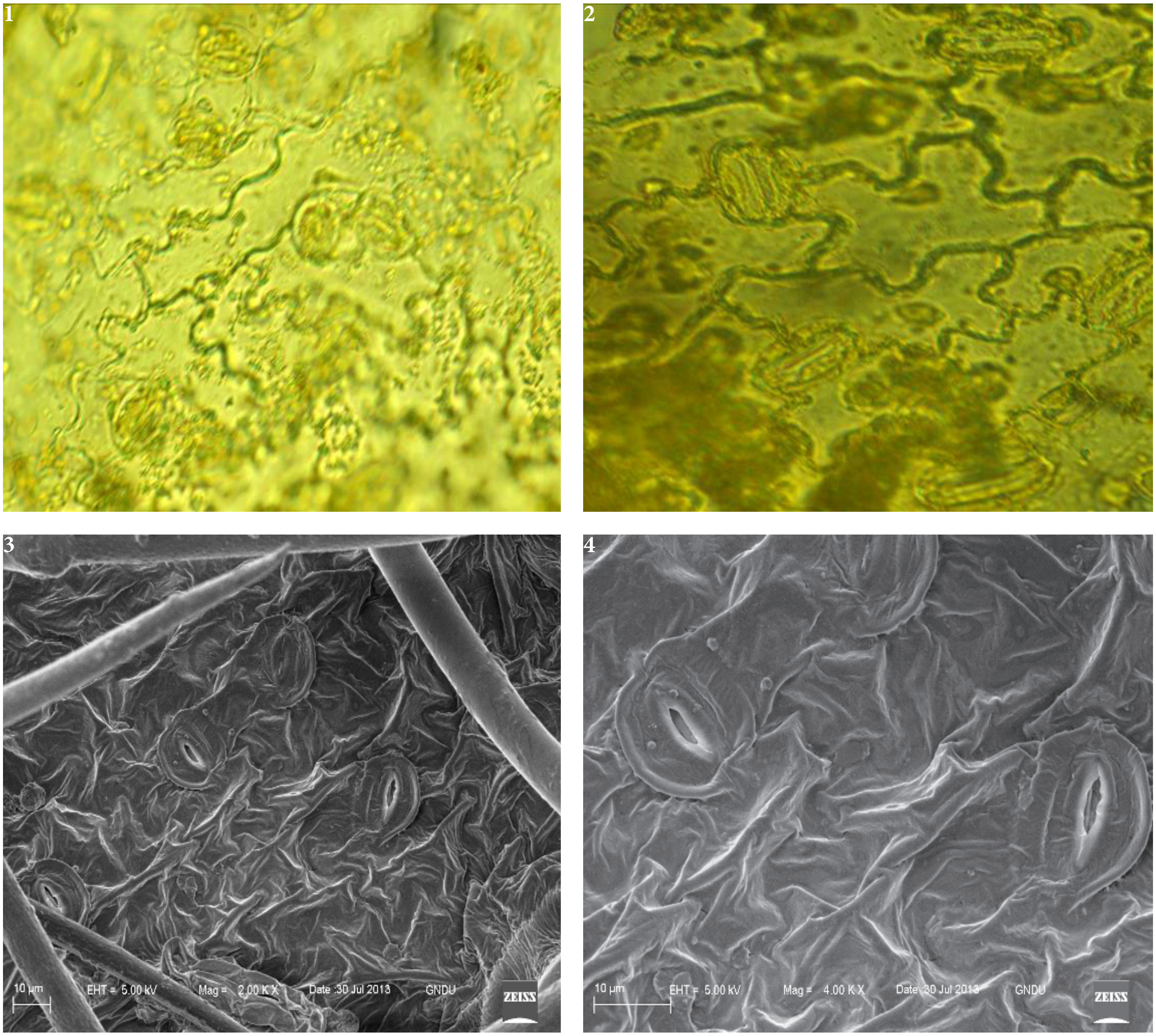

Plate -XII. Light (1 - 2) and Scanning Electron Micrographs (3, 4) of stomata of *Blumea mollis* D. Don.; **1**- abaxial surface (40x); **2**- adaxial surface (100x); **3, 4** - abaxial surface (2.00 Kx, 4.00Kx, scale bar- 10µm, 10 µm).

on adaxial surface of leaves. Length of stomatal pore ranged from 8.69 ± 0.898 (*Verbescinia enceliodes*) to 30.08 ± 0.344 *(Zinnia multiflora*) on abaxial surface of the leaves and 10.49 ± 0.55 (*Verbescinia enceliodes*) to 31.19 ± 0.63 (*Zinnia multiflora*) on adaxial surface of the leaves.

Pataky (1969) classified stomata with guard cells on the basis of size as 'small'-meaning less than 15 µm; medium - between 15 µm and 38 µm; large - meaning more than 38 µm. As can been seen from Table 3, stomata of 13 species were of medium size and only two species Gillardia *pulchella* and *Zinnia multiflora* showed stomata to be of large size. It is generally considered that small stomata gives high stomatal density and that large stomata give low stomatal density (Metcalfe and Chalk, 1988; Beerling and Woodward, 1997). In our study, this statement holds true for *Gillardia pulchella* but not for *Zinnia multiflora* where the size of stomata was maximum among all the species studied but stomatal density was not minimum but rather medium.

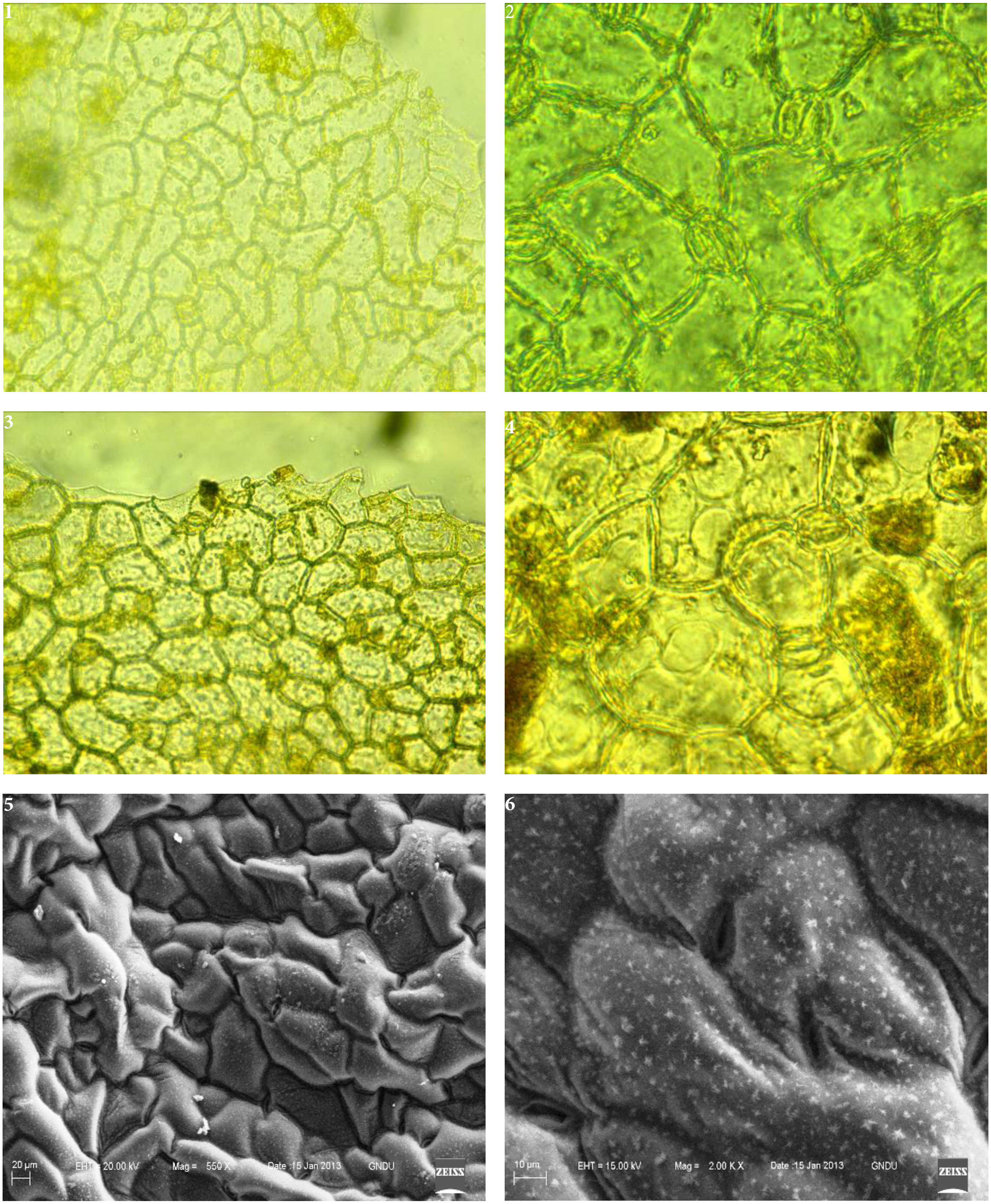

Plate -XIII. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Launaea residifolia* L.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (550x, 2.00Kx, scale bar- 20µm, 10 µm).

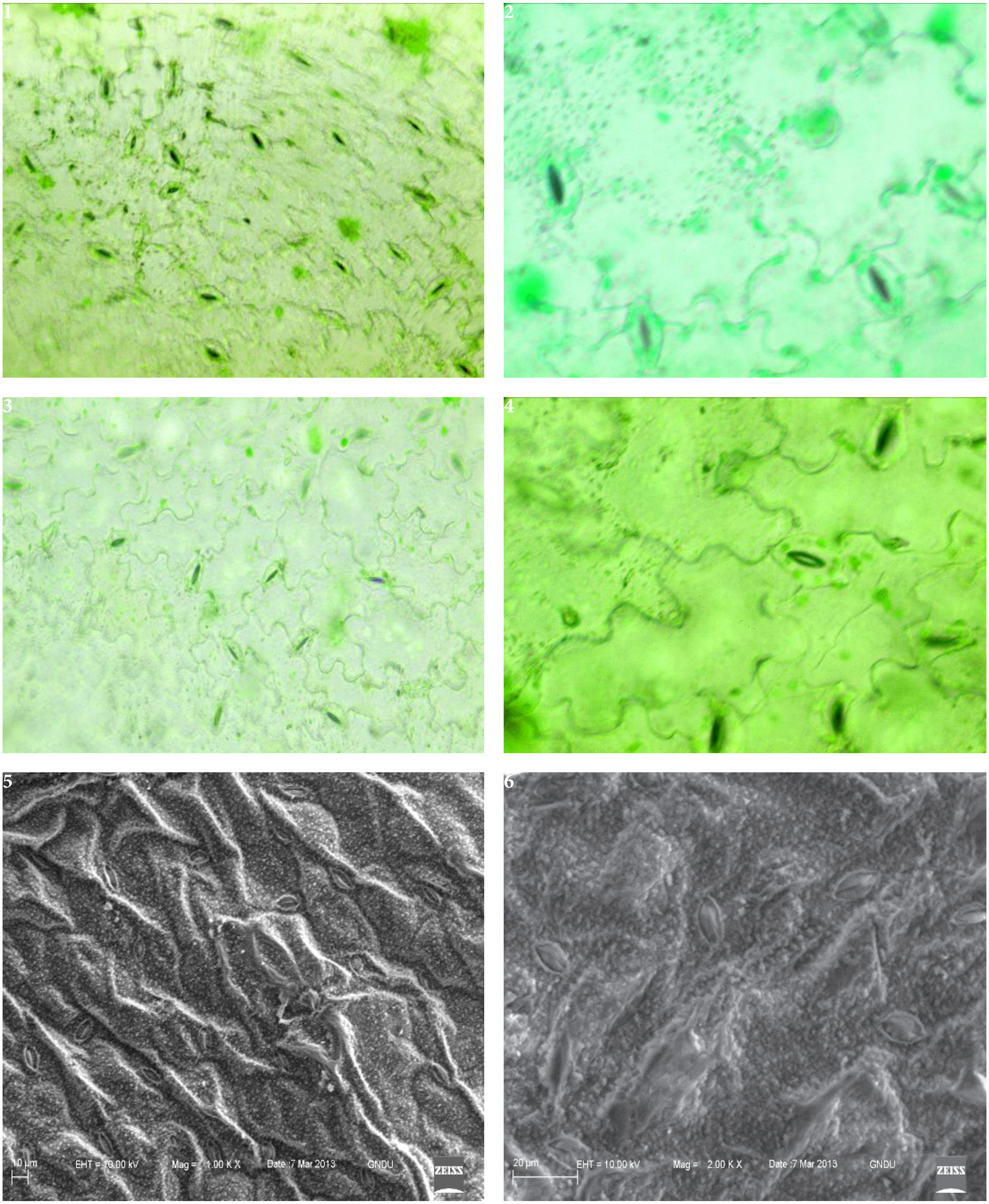

Plate -XIV. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Sonchus oleraceus* L.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (1.00 Kx, 2.00Kx, scale bar- 10µm, 20 µm).

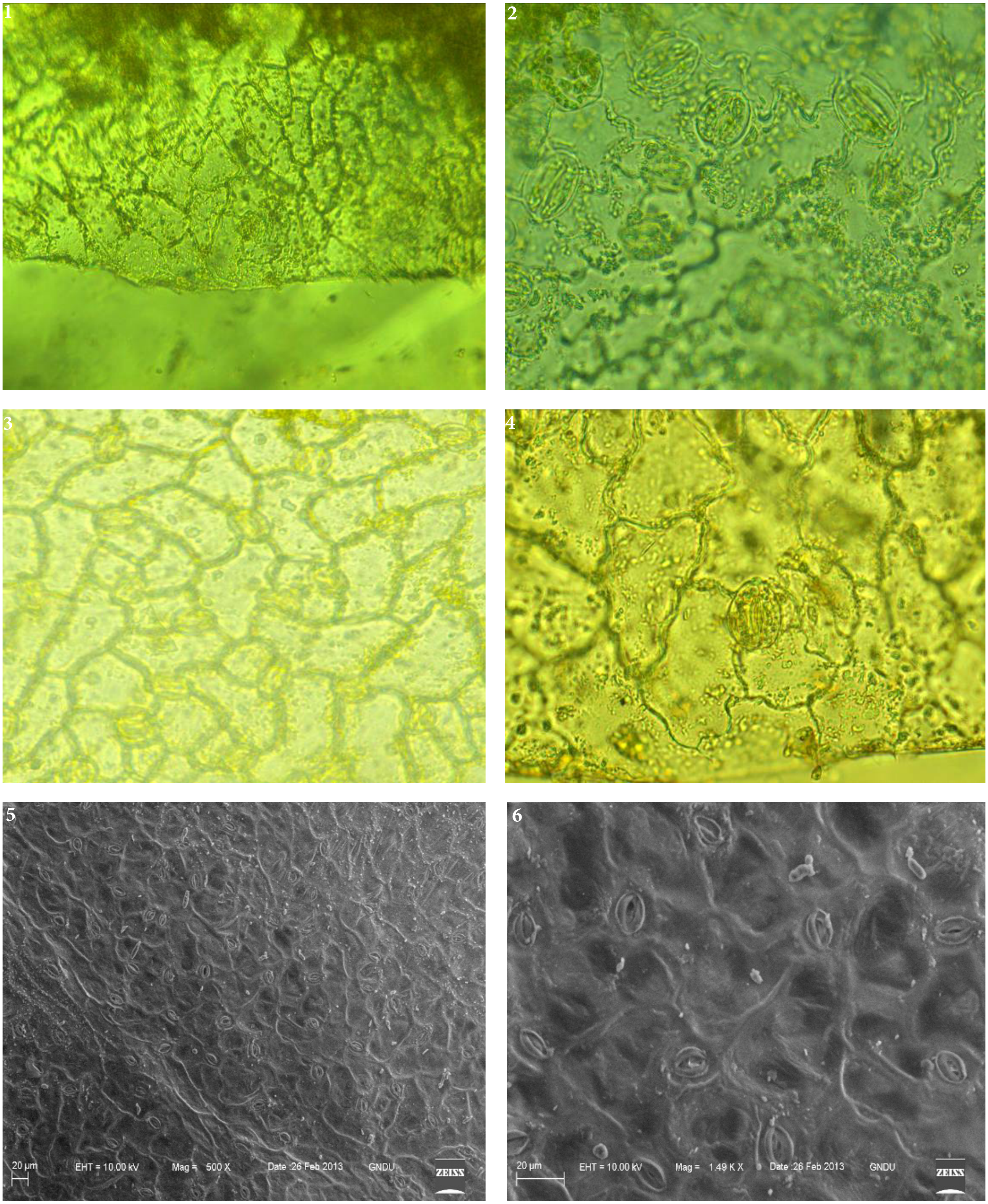

Plate -XV. Light (1 - 4) and Scanning Electron Micrographs (5, 6) of stomata of *Sonchus wightianus* DC.; **1, 2**- abaxial surface (40x, 100x); **3, 4** - adaxial surface (40x, 100x); **5, 6** - abaxial surface (500x, 1.49Kx, scale bar- 20µm, 20 µm)

Table 3: Dimensions and state of open/closed stomata of some species of Asteraceae

Tribe	Sub Tribe	Plant Name	Length of stomata (stomatal pore + guard cells) (µm) (Mean±S.E)		Width of stomata (stomatal pore + guard cells) (µm) (Mean±S.E)		Length of the stomatal pore only (µm) (Mean±S.E)	
			Abaxial	Adaxial	Abaxial	Adaxial	Abaxial	Adaxial
Astereae		*Erigeron bonariensis* L.	25.12 ± 0.58	26.98 ± 0.96	17.66 ± 0.28	19.73 ± 0.40	16.42 ± 0.63	15.59 ± 0.68
Cichorieae	Lactuceae	*Launaea residifolia L.*	25.81 ± 0.77	21.25 ± 0.62	19.41 ± 0.44	16.01 ± 0.22	16.28 ± 0.94	12.7 ± 0.79
		Sonchus oleraceus L.	23.6 ± 0.25	25.81 ± 0.74	20.7 ± 0	13.11 ± 0.31	12.56 ± 0.25	10.76 ± 0.40
		Sonchus wightianus DC.	25.53 ± 0.59	25.94 ± 0.68	19.87 ± 0.75	20.29 ± 0.77	13.87 ± 0.39	13.25 ± 0.90
Heliantheae		*Cosmos bipinnatus* Cav.	28.29 ± 0.72	24.29 ± 0.85	18.35 ± 0.41	16.01 ± 0.62	15.87 ± 0.78	13.8 ± 0.65
		Eclipta alba (L.) Hassk.	17.94± 0.36	23.74 ± 0.54	15.33 ± 0.25	14.77 ± 0.34	12.42 ± 0.36	13.52 ± 0.45
		Gillardia pulchella L.	48.99 ± 0.93	48.16 ± 5.37	32.84 ± 0.54	35.88 ± 0.72	28.29 ± 0.31	30.91 ± 0.23
		Helianthus annuus L.	31.6 ± 0.78	29.95 ± 0.68	21.11 ± 0.65	20.01 ± 0.23	19.87 ± 0.69	19.6 ± 0.28
		Parthenium hysterophorus L.	21.94 ± 0.14	22.08 ± 2.1	16.56 ± 0.00	16.84 ± 0.19	10.76 ± 0.28	11.04 ± 0.36
		Verbescinia enceliodes (Cav.) Bentham & Hooker fil. ex Gray	21.8 ± 1.35	23.18 ± 1.69	19.6 ± 1.16	19.18 ± 1.04	8.694± 0.89	10.49 ± 0.55
		Wedelia trilobata (L.) A.S. Hitchc.	26.22 ±0.65	28.15 ± 0.75	22.77 ± 0.93	22.77 ±0.42	16.56 ± 0.41	16.56 ± 0.29
		Zinnia multiflora L.	52.72 ± 0.54	53.54 ± 0.68	31.46 ± 0.35	36.86 ± 1.18	30.08 ± 0.34	31.19 ± 0.62
Inuleae	Gnaphaleae	*Gnaphalium purpureum* L.	23.46 ± 0	22.08 ± 0.58	20.7 ± 0	16.56 ± 0	13.8 ± 5E-08	12.7 ± 0.54
	Plucheineae	*Blumea mollis* D. Don.	22.36 ± 0.34	24.01 ± 0.47	19.32 ± 0.29	21.25 ± 1.15	13.52 ± 0.34	14.35 ± 0.47
Tageteae		*Tagetes erecta* L.	23.32 ± 0.86	20.84 ± 0.32	14.21 ± 0.21	14.35 ± 0.23	15.18 ± 0.58	13.52 ± 0.28

S. E- Standard Error

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