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PALYNOLOGICAL STUDIES OF WINTER WEEDS MELLIFEROUS FLORA OF DISTRICT BANNU, KHYBER PAKHTUNKHWA, PAKISTAN

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Abstract - The aim of the present study is to investigate the palynological features of the weeds from melliferous point of view. A total of 16 weeds, belonging to 10 different families were collected, pressed, identified and then analyzed microscopically. Both quantitative and qualitative characters of the pollen grains were examined including polar and equatorial diameter, P/E ratio, number of spines, number of colpi and pores, exine thickness and shapes of the pollen in both polar and equatorial view, using Leica microscope fitted with camera Meiji Infinity 1 and then analyzed statistically using software IBM SPSS Statistics 20. The results of the present study highlighted the significance of pollen morphology of the weeds as a bee flora which may lead to the identification of the potential and useful weeds for bee keepers and to increase the honey production from the study area.

Keywords: weeds; melliferous flora; Bannu; pollen; honey

Introduction

Melliferous plants with fragrant and colorful flowers, blooming and growing abundantly, provide the honey bees with the pollen, nectar and honeydew to produce honey, includes both wild as well as cultivated species (Hrynko et al., 2019). Weedy melliferous flora is comprised of plants whose flowers are frequently visited by honeybees to collect nectars and pollens. The melliferous study helps to examine the botanical origin, topographical features of the area and floral diversity from which honeybees collects pollen and frequently foraging (Ponnuchamy et al., 2014). These studies helped in the implication of latest techniques to determine the purity and impurity of the honey. Different flowers are characterized with varied sizes, shapes, colors, number of pollen and nectar types, due to which variations occurred in the honey taste and quality (Agwu et al., 2013).

Weeds are the unwanted plants growing in irrelevant places of the fields (Khan et al., 2013a). Weeds usually intervenes with the associated growing plants (Rahmatullah et al., 2009). Incursive weeds causes high risks to the yield of crops, habitat and physique of the organisms all over the world (Adkins & Navie, 2006; Schmidt & Drake, 2011). These plants usually invade the desired field crops and in turn poses great threat to crop yield. Soil is bestowed with essential nutrients involving micro and macro elements, water, minerals, sunlight, availability of carbon dioxide, nitrogen in the case of leguminous weeds and for some other nutrient rich matters, where the weeds and the desired plants compete with each other to get these substances faster than the other (Mehsud et al., 2013). The leguminous plants extract nitrogen from the environment, converting them into

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nitrogen rich compounds to elevate the growth of beneficial microbes specifically rhizobia which is appraised to assess the fertility of soil (Amarger, 2001). Weed reduces the annual production of crops, and causes destruction of fruits, seeds, vegetables, cereals and fodders have been observed due to the involvement of weeds in the crop fields and fruit gardens (Jakhar et al., 2005). Marwat et al. (1993) carried out the survey of weeds in Pakistan and recorded above 50 weeds which were parasitic in nature. Weeds are common and found in almost every family but most abundant in some families such as Compositae, Cruciferae, Poaceae and Convolvulaceae all over the globe (Nasir & Ali, 1972; Ditomaso & Healy, 2007). The quality and color of the honey depends on the plants from which the bees collected the pollen to produce honey. Weedy melliferous flora has proved the significance of these weeds in the formation of honeys, and also in pollination of the other important plants which is crucial for their reproduction and propagation.

The diversity of the flora of an area has great importance and their natural habitats has frequently been interpreted as the result of the intensity of a struggle for existence between nearly related life forms. Palynology is one of the supreme field in the studies of plant systematics and biodiversity for the determination of plant species found in a specific area (Zafar et al., 2006).

Bannu is one of the southern district of Khyber Pakhtunkhwa, links its borders of land with Karak in the North, Waziristan in the West, Lakki Marwat in the East. It covers 1227 km^2 area and is situated between 32.43°-33.06° North and 70.22°-70.57° East direction (Khan et al., 2013b). River Kurram is one the main river in the district and is a low structural basin. The district consists of a great alluvial plain, with general elevation of 300-600 meters. The foot hill area is characterized with stiff clay, covered by layers of stones and pebbles. In winter temperatures fluctuates between 5 ºC and 17 ºC. Most of the area is cultivated, climate is steppe and annual rainfall is short. The area has no regular forestation and nearly one hundred hectares of land is irrigated by means of tube wells and canals. The major crops of the area are wheat, maize, sugarcane and barley. According to the District Census Report 1998, the area was spontaneously occupied by cultivated and wild trees and other important bee flora including *Morus alba* L., *Morus nigra* L., *Acacia arabica* (Lam.) Willd., *Tamarindus indica* L., *Salix* sp., *Ziziphus* sp. and *Eucalyptus* sp., which are nearly or totally vanished and replaced by unwanted plants and weeds now. These plants are considered as the best pollen source for the honey bees to produce the supreme quality honey. The global climatic changes and human impacts have caused the irreversible destruction to this important flora which in turn caused the scarcity of nectar and pollen source for foraging. Honey production is a lucrative business in Bannu and Karak. Best and exportable quality honey is produced in the Bannu district which meets the international honey quality standards (Qamer et al., 2013).

The aim of the present study is to provide complete information about the palyno-morphological characters of the winter weedy melliferous flora of district Bannu using light microscopic (LM) techniques, which may lead to the identification of useful weeds for bee keepers of the study area to produce honey in the winter season.

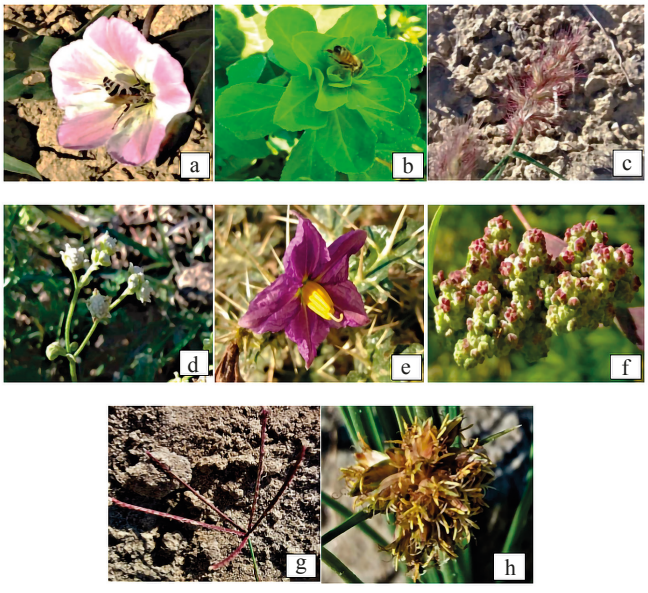

Figure 1. Plants Collected: (a) *Convolvulus arvensis,* L. (b) *Euphorbia helioscopia* L., (c) *Cenchrus ciliaris* L., (d) *Parthenium hysterophorus* L., (e) *Solanum surattense* Burm. f., (f) *Chenopodium murale* L., (g) *Cynodon dactylon* (L.) Pers., (h) *Cyperus compressus* L.

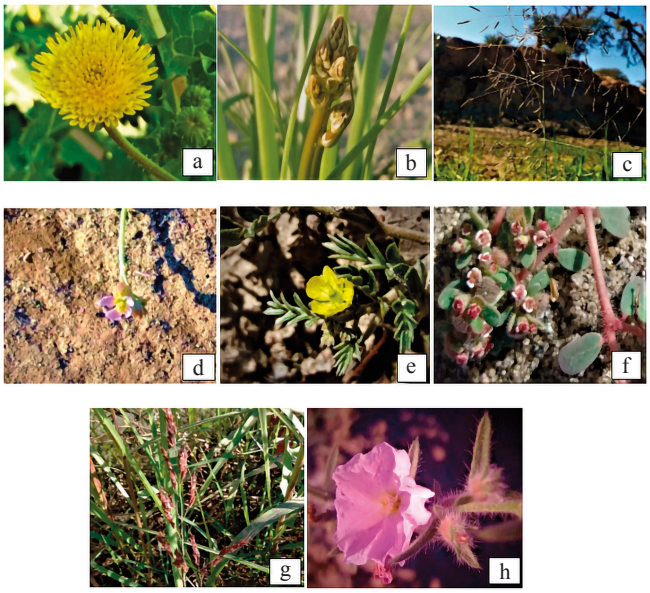

Figure 2. Plants Collected: (a) *Sonchus asper* (L.) Hill, (b) *Asphodelus tenuifolius* Cav., (c) *Eragrostis pilosa* (L.) P.Beauv., (d) *Farsetia stylosa* R.Br., (e) *Tribulus terrestris* L., (f) *Euphorbia prostrata* Aiton, (g) *Sorghum halepense* (L.) Pers., (h) *Convolvulus prostratus* Forssk.

Materials and Methods

Plant Collection

Field work was conducted during the months of December and January at different localities of District Bannu. Plants were observed carefully to confirm the honey bee foraging, and then the weeds which were the most visited by the honey bees were selected and photographed (Fig. 1 and Fig. 2). A total of 16 plants were confirmed as bee flora and then collected, pressed and dried and brought to the Plant Systematics and Biodiversity Laboratory, Quaid-i-Azam University Islamabad for the identification and further experimentation. Botanical names were verified from the Kew Botanical Garden correct scientific name service-The Plant List (www.theplantlist.org). The general description including correct botanical names, vernacular names, collection site, distribution in Pakistan and worldwide distribution are presented in Table 1.

Table 1. Botanical names, collection site, Family and distribution of collected plants.

S. No.	Taxon	Local name	Family	Collection Site	Cultivation Status / Distribution in Pakistan	Distribution in World
1	*Convolvulus arvensis* L.	Pherkhathonai	Convolvulaceae	Kotka Feroz	Wild / Throughout the Pakistan	Pakistan, India, China, Russia, North and South Korea.
2	*Euphorbia helioscopia* L.	Khosayi bethye	Euphorbiaceae	Taji Kali	Wild / Bannu, Islamabad, Rawalpindi and Fateh Jhang	Pakistan, China, Iran, Iraq, Egypt, Canada, Qatar, Turkey, Italy and Norway.
3	*Cenchrus ciliaris* L.	Begharhye	Poaceae	Kotka Feroz	Wild / Khyber Pakhtunkhwa, Punjab, Sindh and Balochistan.	Pakistan, India, USA, Indonesia, Brazil, Italy, UK, Saudi Arabia, Syria and Sudan.
4	*Parthenium hysterophorus* L.	Gand bhootye	Asteraceae	Bank of river Kurram	Wild / Peshawar, Bannu, Lakki Marwat, Gujrat, Islamabad and Rawalpindi.	Pakistan, China, USA, India, South Africa, Sweden and Brazil.
5	*Solanum surattense* Burm. f.	Ghat begharhai	Solanceae	Dowa	Wild / Throughout the Pakistan	Pakistan, India, Iran and North Africa
6	*Chenopodium murale* L.	Sophrye	Amaranthaceae	Khorma	Wild / Bannu, Kohat, Lakki Marwat, Dera Ismail Khan and Dera Ghazi Khan	Pakistan, Afghanistan, Iran, Iraq, Egypt, Canada, France, Germany, Italy and USA.
7	*Cynodon dactylon* (L.) Pers.	Payya	Poaceae	Boza khel	Wild / Throughout the Pakistan	Pakistan, India, Indonesia, Iran, Egypt, Malaysia, Turkey and Sri Lanka.
8	*Cyperus compressus* L.	Dela	Cyperaceae	Rerha	Wild / Bannu, Peshawar, Lakki Marwat, Karak and Dera Ismail Khan.	Pakistan, India, China, Japan, Sri Lanka, Egypt, Sudan and USA.
9	*Sonchus asper* (L.) Hill	Machala	Asteraceae	Taji kali	Wild / Bannu, Dera Ismail Khan, Gujranwala, Rawalpindi and Islamabad	Pakistan, India, China, Afghanistan, Iran, Iraq, Turkey, Canada, Brazil and USA.
10	*Asphodelus tenuifolius* Cav.	Peoaz	Asphodeliaceae	Dowa	Wild / Bannu, Swabi, Kohat, Lakki Marwat and Tank.	Pakistan, India, North Africa, Afghanistan, Iran, Iraq, Saudi Arabia, Turkey and USA.
11	*Eragrostis pilosa* (L.). P. Beauv	Khor bethye	Poaceae	Taji kali	Wild / Bannu, South Waziristan, Lakki Marwat and Karak.	Pakistan, India, Indonesia, Brazil, Germany, Japan and Saudi Arabia.
12	*Farsetia stylosa* R. Br.	Wezo meli	Brassicaceae	Bannu link road	Wild / Bannu, Kohat, South Waziristan and Tank	Pakistan, India, Algeria, Egypt and Indonesia.
13	*Tribulus terrestris* L.	Corenda	Zygophyllaceae	Bannu link road	Wild / Bannu, Peshawar and Kohat.	Pakistan, India, Iraq, Italy, South Africa,. Germany, Australia and USA.
14	*Euphorbia prostrata* Aiton	Kharpharhy	Euphorbiaceae	Rerha	Wild / Bannu, Kasur, Tank and South Waziristan	Pakistan, America, South Africa and Zimbabwe
15	*Sorghum halepense* (L.) Pers.	Washkay	Poaceae	Bank of river Kurram	Wild / Throughout the Pakistan	Pakistan, India, Turkey, Japan, Iran, Germany, Saudi Arabia and Brazil.
16	*Convolvulus prostratus* Forssk.	Lashty	Convolvulaceae	Dowa	Wild / Bannu, Dera Ismail Khan, Tank, Charsada and Lakki Marwat	Pakistan, India, Egypt and Afghanistan

Micro-Morphological Examination of Pollen Using Light Microscopy (LM)

For microscopic studies, mature flowers were selected and dissected with the help of forceps and pollen grains were placed on the slide. The pollen were then passed on to the process of acetolysis according to the method of Erdtman (1952) with few modifications. Pollen grains were crushed and then stained with glycerin jelly. Slide was covered using glass cover slips and sealed with transparent nail enamel. Both quantitative and qualitative characters were recorded including polar diameter, equatorial diameter, P/E ratio, length, width and number of colpi, length and width of spines and exine thickness with the help of Light microscope Meiji Techno MT4300H and then labelled slides were photographed by using microscope Leica D1000 fitted with camera Meiji Infinity 1.

Statistical Analysis

To calculate standard mean values, five consecutive values were noted for each feature. Mean values and standard error were calculated by using statistical software IBM SPSS Statistics 20. Measurements are presented as mean ± Standard error and minimum-maximum range in tabular form (Table 2 and Table 3).

Results

The pollen grains of 16 species of weedy melliferous plants, belonging to 10 different families were examined carefully through light microscopy which were not only unwanted

Table 2. Studied Materials.

S. No.	Taxa	Collector	Locality/District	Voucher number	Province/ Country	Date
1	*Convolvulus arvensis* L.	Shabir and Saqib	Kotka Feroz/ Bannu	ISL-SB-813	Khyber Pakhtunkhwa/ Pakistan	07-12-2018
2	*Euphorbia helioscopia* L.	Shabir and Ishfaq	Taji Kali/ Bannu	ISL-SB-820	Khyber Pakhtunkhwa/ Pakistan	15-12-2018
3	*Cenchrus ciliaris* L.	Shabir and Shakeel	Kotka Feroz/ Bannu	ISL-SB-824	Khyber Pakhtunkhwa/ Pakistan	05-12-2018
4	*Parthenium hysterophorus* L.	Shabir	Bank of river Kurram/ Bannu	ISL-SB-811	Khyber Pakhtunkhwa/ Pakistan	05-12-2018
5	*Solanum surattense* Burm. f.	Shabir et al.	Dowa/ Bannu	ISL-SB-816	Khyber Pakhtunkhwa/ Pakistan	16-12-2018
6	*Chenopodium murale* L.	Shabir and Saqib	Khorma/ Bannu	ISL-SB-844	Khyber Pakhtunkhwa/ Pakistan	07-12-2018
7	*Cynodon dactylon* (L.) Pers.	Shabir and Shakeel	Boza Khel/ Bannu	ISL-SB-836	Khyber Pakhtunkhwa/ Pakistan	05-12-2018
8	*Cyperus compressus* L.	Shabir et al.	Rerha/ Bannu	ISL-SB-840	Khyber Pakhtunkhwa/ Pakistan	16-12-2018
9	*Sonchus asper* (L.) Hill	Shabir and Saqib	Taji Kali/ Bannu	ISL-SB-838	Khyber Pakhtunkhwa/ Pakistan	07-12-2018
10	*Asphodelus tenuifolius* Cav.	Shabir and Shakeel	Dowa/ Bannu	ISL-SB-825	Khyber Pakhtunkhwa/ Pakistan	05-12-2018
11	*Eragrostis pilosa* (L.) P. Beauv.	Shabir and Ishfaq	Taji Kali/ Bannu	ISL-SB-882	Khyber Pakhtunkhwa/ Pakistan	15-12-2018
12	*Farsetia stylosa* R. Br.	Shabir and Saqib	Bannu link road/ Bannu	ISL-SB-818	Khyber Pakhtunkhwa/ Pakistan	07-12-2018
13	*Tribulus terrestris* L.	Shabir and Ishfaq	Bannu link road/ Bannu	ISL-SB-833	Khyber Pakhtunkhwa/ Pakistan	15-12-2018
14	*Euphorbia prostrata* Aiton	Shabir	Rerha/ Bannu	ISL-SB-827	Khyber Pakhtunkhwa/ Pakistan	05-12-2018
15	*Sorghum halepense* (L.) Pers.	Shabir and Shakeel	Bank of river Kurram/ Bannu	ISL-SB-824	Khyber Pakhtunkhwa/ Pakistan	05-12-2018
16	*Convolvulus prostratus* Forssk.	Shabir and Saqib	Dowa/ Bannu	ISL-SB-839	Khyber Pakhtunkhwa/ Pakistan	07-12-2018

Key: ISL = Herbarium of Pakistan (ISL), Quaid-i-Azam University Islamabad, Pakistan

Table 3. Micro-morphological characteristics of Pollen-Quantitative.

S. No.	Taxon	P/E ratio	Exine thickness	Polar diameter	Equatorial diameter	Length of colpi	Width of colpi	Length of spine	Width of spine
					(µm)				
1	*Convolvulus arvensis* L.	1.25	2.37±0.29	49.65±4.62	39.75±0.40	13.20± 2.33	6.84±0.40	A	A
	(Min-Max)		1.50-3.15	43.35-67.95	38.40-41.10	8.10-21.30	5.70-8.10	-	-
2	*Euphorbia helioscopia* L.	0.99	1.41±0.07	28.17±1.49	28.29±1.31	13.56±2.39	7.62±1.25	A	A
	(Min-Max)		1.20-1.65	22.65-30.75	24.60-31.50	6.15-19.05	5.70-12.45	-	-
3	*Cenchrus ciliaris* L.	1.02	1.20± 0.11	28.11± 2.34	27.45± 1.54	A	A	A	A
	(Min-Max)		0.90-1.50	23.25-34.05	24.30-33.30	-	-	-	-
4	*Parthenium hysterophorus* L.	0.98	1.59±0.14	13.14±0.46	13.41±0.86	1.92±0.13	3.78±0.81	1.41± 0.15	1.62±0.13
	(Min-Max)		1.20-1.95	12.00-14.70	12.15-16.80	1.65-2.40	1.80-6.00	0.90-1.80	1.20-1.95
5	*Solanum surattense* Burm. f.	0.95	1.23±0.87	18.12±0.45	19.05±0.47	5.40±1.01	4.05±0.60	A	A
	(Min-Max)		1.05-1.50	16.65-19.50	17.70-20.40	2.70-8.55	2.40-5.70	-	-
6	*Chenopodium murale* L.	0.86	1.53±0.13	16.17±1.18	18.75±1.98	A	A	A	A
	(Min-Max)		1.20-1.95	12.75-19.8	15.45-26.4				
7	*Cynodon dactylon* (L.) Pers.	0.86	1.44±0.12	16.32±1.13	21.93±1.84	A	A	A	A
	(Min-Max)		1.20-1.80	13.50-18.75	19.35-29.10	-	-	-	-
8	*Cyperus compressus* L.	0.90	0.96±0.07	15.69±1.14	17.46±2.08	2.55±0.52	2.79±0.23	A	A
	(Min-Max)		0.75-1.20	12.60-18.45	13.20-25.20	1.50-4.35	2.10-3.45	-	-
9	*Sonchus asper* (L.) Hill	0.81	1.38±0.17	20.82±0.87	25.56±0.44	4.65±1.06	4.95±0.79	1.38±0.21	1.44±0.23
	(Min-Max)		0.90-1.95	18.60-25.95	24.3-28.05	2.70-8.10	3.00-7.65	0.90-2.10	0.90-2.25
10	*Asphodelus tenuifolius* Cav.	0.94	0.99±0.16	39.72± 4.08	41.90± 2.70	A	A	A	A
	(Min-Max)		0.60-1.50	23.70-46.05	31.80-48.15	-	-	-	-
11	*Eragrostis pilosa* (L.) P. Beauv.	0.89	1.14 ±0.14	17.70±0.52	19.89±1.17	A	A	A	A
	(Min-Max)		0.75-1.50	16.20-19.20	17.10-23.40	-	-	-	-
12	*Farsetia stylosa* R. Br.	0.84	1.50±0.11	14.91±0.56	17.64± 0.77	5.04±0.74	4.65±0.73	A	A
	(Min-Max)		1.20-1.80	13.50-16.50	15.15-19.80	2.70-6.90	2.10- 6.00	-	-
13	*Tribulus terrestris* L.	0.97	1.08± 0.19	33.39±2.67	34.38± 2.13	4.23±0.74	6.18± 1.79	1.41±0.19	1.65± 0.13
	(Min-Max)		0.60-1.65	25.95-39.15	29.10-39.90	2.40-5.85	3.60-13.20	0.75-1.95	1.20-1.95
14	*Euphorbia prostrata* Aiton	1.03	1.65± 0.23	12.99±0.78	12.63± 0.36	3.27±0.43	2.16 ±0.47	A	A
	(Min-Max)		1.20-2.55	10.50-15.15	11.55-13.35	1.80-4.20	1.20-3.75	-	-
15	*Sorghum halepense* (L.) Pers.	0.96	1.11±0.08	32.43± 4.48	33.72±0.36	A	A	A	A
	(Min-Max)		0.90-1.35	15.15-40.65	32.55-34.50	-	-	-	-
16	*Convolvulus prostrates* Forssk.	0.93	2.07± 0.20	32.7± 1.52	34.89± 2.02	13.74± 1.96	15.24± 0.89	A	A
	(Min-Max)		1.65-2.85	28.35-37.80	28.95-40.20	10.20-20.70	12.45-17.25	-	-

Key: P/E ratio = Polar to equatorial ratio, Min = minimum, Max = maximum, SE = standard error, A = absent, µ = micro meter

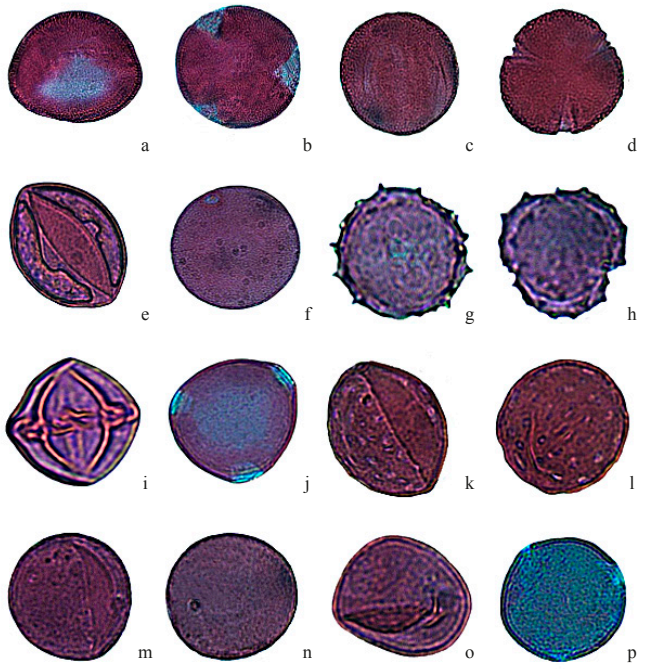

Figure 3. Light microscopy pollen micrographs. *Convolvulus arvensis* L.: (a) Equatorial view, (b) Polar view; *Euphorbia helioscopia* L.: (c) Equatorial view, (d) Polar view; *Cenchrus ciliaris* L.: (e) Equatorial view, (f) Polar view; *Parthenium hysterophorus* L.: (g) Equatorial view, (h) Polar view; *Solanum surattense* Burm. f.: (i) Equatorial view, (j) Polar view; *Chenopodium murale* L.: (k) Equatorial view, (l) Polar view; *Cynodon dactylon* (L.) Pers.: (m) Equatorial view, (n) Polar view; *Cyperus compressus* L.: (o) Equatorial view, (p) Polar view.

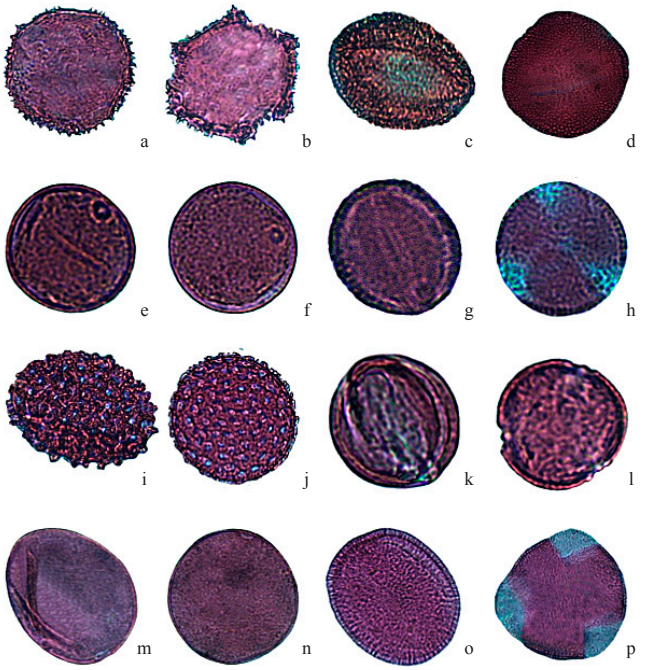

Figure 4. Light microscopy pollen micrographs. *Sonchus asper* (L.) Hill: (a) Equatorial view, (b) Polar view; *Asphodelus tenuifolius* Cav.: (c) Equatorial view, (d) Polar view; *Eragrostis pilosa* (L.) P.Beauv.: (e) Equatorial view, (f) Polar view; *Farsetia stylosa* R.Br.: (g) Equatorial view, (h) Polar view; *Tribulus terrestris* L.: (i) Equatorial view, (j) Polar view; *Euphorbia prostrata* Aiton: (k) Equatorial view, (l) Polar view; *Sorghum halepense* (L.) Pers.: (m) Equatorial view, (n) Polar view; *Convolvulus prostratus* Forssk.: (o) Equatorial view, (p) Polar view.

plants but also possesses the melliferous values. Both the qualitative and quantitative features of the pollen grains were recorded and presented in tabular form (Table 2 and Table 3). Pollen micrographs in both equatorial and polar views are presented in Fig. 3 and 4.

***Convolvulus arvensis* L.**
(Convolvulaceae)

English name: Field bindweed

Flowering periods: October-March

Flower color: White-Pink

Palynomorph: The pollen is monad, tricolporate and psilate. Its polar diameter is 49.65 µm (43.35-67.95 µm), equatorial diameter is 39.75 µm (38.40-41.10 µm), P/E ratio is 1.25 µm and exine thickness is 2.37 µm (1.50-3.15 µm). Shape of the pollen is subprolate.

***Euphorbia helioscopia* L.**
(Euphorbiaceae)

English name: Sun spurge

Flowering periods: November-April

Flower color: Yellow

Palynomorph: The pollen is monad, tricolporate and psilate. The pollen polar diameter is 28.17 µm (22.65-30.75 µm), equatorial diameter is 28.29 µm (24.60-31.50 µm), P/E ratio is 0.99 µm and exine thickness is 1.41 µm (1.20-1.65 µm). Shape of the pollen is oblate-spheroidal.

***Cenchrus ciliaris* L.**
(Poaceae)

English name: Buffel grass

Flowering periods: March-December

Flower color: Purple

Palynomorph: The pollen is monad, monoporate and psilate. Its polar diameter is 28.11 µm (23.25-34.05 µm), equatorial diameter is 27.45 µm (24.30-33.30 µm), P/E ratio is 1.02 µm and exine thickness is 1.20 µm (.90-1.50 µm). Shape of the pollen is prolate-spheroidal.

***Parthenium hysterophorus* L.**
(Asteraceae)

English name: Congress grass

Flowering periods: July-December

Flower color: White

Palynomorph: The pollen is monad, trizonocolporate and echinate. The pollen polar diameter is 13.14 µm (12.00-14.7 µm), equatorial diameter is 13.41 µm (12.15-16.80 µm), P/E ratio is 0.98 µm and exine thickness is 1.59 µm (1.20-1.95 µm). Shape of the pollen is oblate-spheroidal.

***Solanum surattense* Burm. f.**
(Solanaceae)

English name: Wild eggplant

Flowering periods: October-January

Flower color: Purple

Palynomorph: The pollen is monad, tricolporate and psilate. Its polar diameter is 18.12 µm (16.65-19.50 µm), equatorial diameter is 19.05 µm (17.70-20.40 µm), P/E ratio is 0.95 µm and exine thickness is 1.23 µm (1.05-1.50 µm). Shape of the pollen is oblate-spheroidal.

***Chenopodium murale* L.**
(Amaranthaceae)

English name: Nettle leaved goosefoot

Flowering periods: November- April

Flower color: Green-Purple

Palynomorph: The pollen is monad, pentaporate to polyporate and psilate. Its polar diameter is 16.17 µm (12.75-19.8 µm), equatorial dimeter is 18.75 µm (15.45-26.4 µm), P/E ratio is 0.86 µm and exine thickness is 1.53 µm (1.20-1.95 um). Shape of the pollen is suboblate.

***Cynodon dactylon* (L.) Pers.**
(Poaceae)

English name: Dhub grass

Flowering periods: March-December

Flower color: Purple

Palynomorph: The pollen is monad, monoporate and psilate. The pollen polar diameter is 16.32 µm (13.50-18.75 µm), equatorial diameter is 21.93 µm (19.35-29.10 µm), P/E ratio is 0.86 µm. Shape of the pollen is suboblate.

***Cyperus compressus* L.**
(Cyperaceae)

English name: Annual sedge

Flowering periods: July-January

Flower color: Brown-purple

Palynomorph: The pollen is of two types, i.e. apolar and heteropolar. Its polar diameter is 15.69 µm (12.60-18.45 µm), equatorial diameter is 17.46 µm (13.20-25.20 µm), P/E ratio is 0.90 µm and exine thickness is 0.90 µm (0.75-1.20 µm). Shape of the pollen is oblate-spheroidal.

***Sonchus asper* (L.) Hill**
(Asteraceae)

English name: Prickly sow-thistle

Flowering periods: November-March

Flower color: Yellow

Palynomorph: The pollen is trizonocolporate and echinate. Its polar diameter is 20.82 µm (18.60-25.95 µm), equatorial diameter is 25.56 µm (24.3-28.05 µm), P/E ratio is 1.03 µm and exine thickness is 1.38 µm (0.90-1.95 µm). Shape of the pollen is suboblate.

***Asphodelus tenuifolius* Cav.**
(Asphodeliaceae)

English name: Onion weed

Flowering periods: December-May

Flower color: White-Reddish brown

Palynomorph: Its pollen grain is isobisymmetrical. The polar diameter of the pollen is 39.72 µm (23.70-46.05 µm), equatorial diameter is 41.90 µm (31.80-48.15 µm), P/E ratio is 0.94 µm and exine thickness is 0.99 µm (0.60-1.50 µm). Shape of the pollen is oblate-spheroidal.

***Eragrostis pilosa* (L.) P.Beauv.**
(Poaceae)

English name: Soft love grass

Flowering periods: November-March

Flower color: Purple

Palynomorph: The pollen is monad, monoporate and psilate. Its polar diameter is 17.70 µm (16.20-19.20 µm), equatorial diameter is 19.89 µm (17.10-23.40 µm), P/E ratio is 0.89 µm and exine thickness is 1.14 µm (0.75-1.50 µm). Shape of the pollen is oblate-spheroidal.

***Farsetia stylosa* R.Br.**
(Brassicaceae)

English name: Honesty plant

Flowering periods: November-April

Flower color: White-Pink

Palynomorph: The pollen is monad, tricolporate and psilate. Its polar diameter is 14.91 µm (13.50-16.50 µm), equatorial diameter is 17.64 µm (15.15-19.80 µm), P/E ratio is 0.84 µm and exine thickness is 1.50 µm (1.20-1.80 µm). Shape of the pollen is suboblate.

***Tribulus terrestris* L.**
(Zygophyllaceae)

English name: Bullhead

Flowering periods: November-April

Flower color: Yellow

Palynomorph: The pollen is tricolporate and pentaporate. Its polar diameter is 33.39 µm (25.95-39.15 µm), equatorial diameter is 34.38 µm (29.10-39.90 µm), P/E ratio is 0.97 µm and exine thickness is 1.08 µm (0.60-1.65 µm). Shape of the pollen is oblate-spheroidal.

***Euphorbia prostrata* Aiton**
(Euphorbiacaeae)

English name: Prostate spurge

Flowering periods: December-April

Flower color: White-Purple

Palynomorph: The pollen is monad, tricolporate and psilate. Its polar diameter is 12.99 µm (10.50-15.15 µm), equatorial diameter is 12.63 µm (11.55-13.35 µm), P/E ratio is 1.03 µm and exine thickness is 1.65 µm (1.20-2.55 µm). Shape of the pollen is prolate-spheroidal.

***Sorghum halepense* (L.) Pers.**
(Poaceae)

English name: Johnson grass

Flowering periods: October-April

Flower color: Brown-Purple

Palynomorph: The pollen is monad, monoporate and psilate. The pollen polar diameter is 32.43 µm (15.15-40.65 µm), equatorial diameter is 33.72 µm (32.55-34.50 µm), P/E ratio is 0.96 µm and exine thickness is 1.11 µm (0.90-1.50 µm). Shape of the pollen is oblate-spheroidal.

***Convolvulus prostratus* Forssk.**
(Convolvulaceae)

English name: Prostrate bindweed

Flowering periods: December-May

Flower color: Pink

Palynomorph: The pollen is monad, tricolporate and psilate. Its polar diameter is 32.7 µm (28.35-37.80 µm), equatorial diameter is 34.89 µm (28.95-40.20 µm), P/E ratio is 0.93 µm and exine thickness is 2.07 µm (1.65-2.85 µm).

Table 4. Micro-morphological characteristics of Pollen-Qualitative.

S. No.	Taxa	Pollen shape	Colpi/pore	Number of Colpi	Spines	Shape of spines
1	*Convolvulus arvensis* L.	Subprolate	A	Tricolporate	A	-
2	*Euphorbia helioscopia* L.	Oblate-Spheroidal	P	Tricolporate	A	-
3	*Cenchrus ciliaris* L.	Prolate-Spheroidal	A	-	A	-
4	*Parthenium hysterophorus* L.	Oblate-Spheroidal	P	Trizonocolporate	P	Small and cylindrical
5	*Solanum surattense* Burm. f.	Oblate-Spheroidal	P	Tricolporate	A	-
6	*Chenopodium murale* L.	Suboblate	A	-	A	-
7	*Cynodon dactylon* (L.) Pers.	Suboblate	A	-	A	-
8	*Cyperus compressus* L.	Oblate-Spheroidal	-	-	A	-
9	*Sonchus asper* (L.) Hill	Suboblate	P	Trizonocolporate	P	Broad and granulated
10	*Asphodelus tenuifolius* Cav.	Oblate-Spheroidal	-	-	A	-
11	*Eragrostis pilosa* (L.) P. Beauv.	Oblate-Spheroidal	A	-	A	-
12	*Farsetia stylosa* R. Br.	Suboblate	P	Tricolporate	A	-
13	*Tribulus terrestris* L.	Oblate-Spheroidal	P	Polycolporate	A	-
14	*Euphorbia prostrata* Aiton	Prolate-Spheroidal	A	-	A	-
15	*Sorghum halepense* (L.) Pers.	Oblate-Spheroidal	A	-	A	-
16	*Convolvulus prostratus* Forssk.	Oblate-Spheroidal	A	Tricolporate	A	-

Key: P = present, A = absent

Discussion

The melliferous weeds investigated in the present study were herbaceous in nature and collected during the months of December and January. It was observed that honeybees visit weedy plants more often than the other plants in these months. *Euphorbia helioscopia* L. was regularly visited by honeybees and Poaceae was the dominant family in the collected plants containing four taxa. Convolvulaceae, Euphorbiaceae and Asteraceae contained two taxa each, while Solanaceae, Amaranthaceae, Cyperaceae, Asphodeliaceae, Brassicaceae and Zygophyllaceae contained one taxon each. The majority of the pollen types were tricolporate, and monoporate, having oblate-spheroidal shape. All the parameters of pollen were examined including qualitative and quantitative characters (Table 2 and 3). *Parthenium hysterophorus* L. and *Sonchus asper* (L.) Hill have spines on the surface of the pollen belonging to family Asteraceae and echinate pollen is the distinguishing character of the family (Figure 1 and 2). The highest P/E ratio was observed in *Convolvulus arvensis* L. (1.25 µm) and lowest in *Sonchus asper* (L.) Hill (0.81 µm). *Convolvulus arvensis* L. was characterized with maximum polar diameter that of 49.65 µm and *Euphorbia prostrata* Aiton had minimum that of 12.99 µm. The maximum equatorial diameter was observed in *Asphodelus tenuifolius* Cav. (41.90 µm) and minimum in *Euphorbia prostrata* Aiton (12.63 µm). *Convolvolus prostrata* Forssk. had maximum length of colpi that is 15.24 µm and *Parthenium hysterophorus* L. had minimum that of 1.92 µm. Maximum colpi length was 15.24 µm observed in *Convolvulus prostrata* Forssk. and minimum length was 2.16 µm in *Euphorbia prostrata* Aiton. *Convolvulus arvensis* L. also possessed maximum thickness of exine that was 2.73 µm and *Cyperus compressus* L. had the minimum value of 0.96 µm.

It was observed that in district Bannu, weeds were mostly produced in the crops of wheat, chickpea, maize and mustard. Weedy melliferous plants grow in the natural environment and are used by the people of a particular area as food for animals, fuels, medicines, constructions and others multiple purpose (Murad et al., 2012). Weed flora depends on the topographical features of the earth (Saaverdra et al., 1990). The taxonomy of weeds mostly depends on the ecological factors including landform, vegetation, water and climate changes (Khan et al., 2013c; Ahmad et al., 2016). The present study revealed the significance of weeds from the melliferous point of view. Therefore, these weeds should not be ignored because they may help in the extension of honey business in the district, which in turn will support the socio-economic uplifting of the local people by motivating them to start their honey business.

The weeds investigated in the present study, belongs to varied families. However, variations were observed in the pollen shapes, its polar diameter, equatorial diameter, exine thickness, number and presence of colpi, pores and spines. The melliferous capacity of each plant is different from the others. The plants from family Labiatae have high melliferous capacity, Compositae, Leguminosae and Umbelliferae have a medium capacity, while Brassicaceae has less melliferous capacity (Ion et al., 2018). Weeds disturb the crops and reduces their annual production due to which clashes occurs between the farmers (Bretagnolle & Gaba, 2015). There is a direct relationship between the diversification of wild honey bees and the weeds (Rollin et al., 2013). Carvalheiro et al. (2011) revealed that a place where weed is abundant, the colonies of wild bees will also be increased there. The aim of the present study was to identify and explore the melliferous flora of Bannu and their significance to further persuade researchers and ecologists to investigate the basic reasons of replacement of beneficial flora with the unwanted plants, changes in the ecology and climate of the area.

Conclusions

The present study reported 16 winter weeds from the study area, which were identified as honey bee flora. This palynological investigation of melliferous flora may help the bee keepers to understand the importance of weeds for the bee keeping business, and they can effectively manage their business even in winter season which may lead to the elevated export of honey by producing the best quality honey. Based on these results, the study area can be considered as the potential area for bee keeping business. Furthermore, this study may provoke the researchers and ecologists in future to find out the ways for the management of both beneficial and unwanted flora in a balanced manner.

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