Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 13, (2024)
https://www.jneonatalsurg.com

OPEN ACCESS

Pollen Spectrum and Bee Flora Diversity in Northern Balochistan, Pakistan: A Melissopalynological Study

Afsana Sherani[1], Tahira Bibi*[2], Shazia Irfan[3], Kanval Shaukat[4], Naheed Sajjad[5], Hina Ali Ahmed[6], Nelofer Jamil[7], Gul Makai[8], Samina Mengal[9], Niaz Muhammad Tareen[10]

[1]Department of Botany, Sardar Bahadur Khan Women's University, Quetta, Pakistan.
Email id : afsisherani@gmail.com
[2]Department of Botany, Sardar Bahadur Khan Women's University, Quetta, Pakistan,
Email id :tahira_botany@yahoo.com
[3] Department of Botany, Sardar Bahadur Khan Women's University Quetta, Pakistan.
Email id : irfanshazia16@gmail.com
[4]Department of Botany, University of Balochistan, Quetta, Pakistan.
Email id : Kanval_shaukat777@yahoo.com
[5]Department of Biotechnology, Sardar Bahadur Khan Women's University, Quetta, Pakistan
Email id: Pakistannaheedsaj@gmail.com
[6] Department of Zoology, Sardar Bahadur Khan Women's University, Quetta, Pakistan.
Email id :hina29_zoo@yahoo.com
[7] Department of Environmental Sciences, Sardar Bahadur Khan Women's University, Quetta, Pakistan.
Email id :nelofer.sbkwu@gmail.com
[8]Department of Zoology, Sardar Bahadur Khan Women's University, Quetta, Pakistan.
Email id : g.makai@yahoo.com
[9]Department of Botany, Sardar Bahadur Khan Women's University, Quetta, Pakistan/ Govt Girls Degree College Khuzdar
Email id :saminamengal7@gmail.com
[10]Balochistan Textbook board Quetta, Pakistan.
Email id : tareenan@yahoo.com
Corresponding Author*
Email: tahira_botany@yahoo.com

Cite this paper as: Afsana Sherani, Tahira Bibi, Shazia Irfan, Kanval Shaukat, Naheed Sajjad, Hina Ali Ahmed, Nelofer Jamil, Gul Makai, Samina Mengal, Niaz Muhammad Tareen, (2024) Pollen Spectrum and Bee Flora Diversity in Northern Balochistan, Pakistan: A Melissopalynological Study. *Journal of Neonatal Surgery*, 13, 1212-1228.

ABSTRACT
Melissopalynology, the study of pollen grains in honey, is a valuable tool for identifying floral resources exploited by bees and for determining the botanical and geographical origin of honey. This study aimed to document the diversity of bee forage plants in Northern Balochistan, Pakistan, and to highlight the region's potential for sustainable apiculture. Five fresh honey samples were collected from local beekeepers in Ziarat, Loralai, Khanozai, Quetta, and Muslimbagh, along with representative plant specimens from the surrounding habitats. Pollen analysis was performed using the acetolysis method, and slides were prepared from floral anthers and honey samples to identify pollen taxa. All honey samples were classified as multifloral. A total of 30 pollen types representing multiple plant families were identified. The dominant taxa included Sonchus oleraceus, Peganum harmala, Helianthus annuus, Malus pumila, and Punica granatum. The family Asteraceae was the most prominent, being consistently present across all honey samples. Seasonal variation in pollen diversity was also observed, with higher representation of taxa during peak flowering periods. The pollen spectrum corresponded closely with the surrounding vegetation, confirming the reliability of melissopalynological analysis. The results demonstrate that the honey of Northern Balochistan is of multifloral origin and reflects the rich floral diversity of the region. These findings highlight the ecological significance of native plant species in sustaining honeybee populations and underscore the potential for developing apiculture as a sustainable livelihood. Conservation of key forage plants is recommended to support both ecological balance and local beekeeping practices..

Keywords: *Melissopalynology, Pollen Spectrum, Bee Forage Plants, Honey Floral Origin, Multifloral Honey, Apicultural, Sustainable Beekeeping*

1. INTRODUCTION

Honeybees (*Apis mellifera* and related species) are among the most important pollinators, playing a crucial role in maintaining biodiversity, supporting agricultural productivity and providing economically valuable products such as honey, wax and propolis (Potts et al., 2010). The composition and quality of honey depend largely on the floral resources available in the region, which are determined by climate, topography and vegetation cover (Adgaba et al., 2017). Understanding the botanical and geographical origin of honey is therefore essential not only for honey authentication but also for promoting sustainable apiculture and biodiversity conservation. Melissopalynology, the study of pollen grains in honey, has emerged as a widely used technique to characterize the botanical origin of honey and to identify the diversity of bee forage plants (Von der Ohe et al., 2004). By analyzing the pollen assemblages present in honey samples, researchers can reconstruct the floral composition of an area and evaluate the extent of plant–pollinator interactions (Louveaux, Maurizio, & Vorwohl, 1978). Beyond honey authentication, melissopalynological studies provide insights into regional flora, ecological dynamics and the potential of apiculture as a livelihood option in rural communities (Song, Liu, & Wang, 2012). Pakistan has diverse agro-climatic zones and rich floral resources, making it suitable for beekeeping and honey production (Khan et al., 2022). However, systematic studies documenting the diversity of bee forage plants through pollen analysis remain limited, particularly in arid and semi-arid regions such as Balochistan. Northern Balochistan, characterized by rugged mountains, semi-arid climate and seasonal vegetation, harbors a unique assemblage of native and cultivated flora that supports honeybee populations (Shah et al., 2020). Despite this ecological richness, the beekeeping industry in the region remains underdeveloped, largely due to a lack of scientific knowledge, inadequate awareness among local communities, and limited policy support (Junaid et al., 2020). Melissopalynological studies conducted in various parts of the world have consistently highlighted the significance of pollen analysis for understanding honey composition. For instance, Al-Khalifa and Al-Arify (1999) studied Saudi Arabian honeys and identified dominant pollen types reflecting desert flora, while Persano Oddo and Piro (2004) emphasized the role of pollen analysis in standardizing honey quality across Europe. In South Asia, Gyawali, (2025) documented the pollen spectrum of honey in Nepal, reporting strong correspondence between pollen composition and local vegetation. In Pakistan, recent studies have begun to shed light on melissopalynology in regions such as Punjab and Khyber Pakhtunkhwa (Kausar et al., 2024; Khan et al., 2022), yet Balochistan remains largely unexplored in this regard.The family *Asteraceae* is among the most common contributors to pollen spectra worldwide, often dominating honey samples in both tropical and temperate environments (Louveaux et al., 1978; Kausar et al., 2024). Similarly, taxa such as *Helianthus annuus* (sunflower), *Punica granatum* (pomegranate), and *Malus pumila* (apple) are widely recognized as significant nectar and pollen sources for bees (Khan et al., 2022). The presence of both wild and cultivated plants in honey samples reflects the adaptability of bees to diverse floral resources and underscores the importance of conserving native vegetation alongside agricultural crops. From an economic perspective, melissopalynological studies also serve as a tool for honey authentication, enabling producers to label honey according to its floral and geographical origin (Von der Ohe et al., 2004). Such practices are critical for building consumer trust, ensuring fair trade, and expanding market opportunities for local beekeepers. In regions like Northern Balochistan, where rural livelihoods often depend on subsistence agriculture and livestock rearing, the promotion of beekeeping could diversify income sources and contribute to poverty alleviation (Junaid et al., 2020). In addition, melissopalynology can serve as a proxy for monitoring environmental change and biodiversity loss. Changes in the pollen spectrum of honey over time may reflect alterations in land use, climate change impacts, or the decline of key floral resources (Potts et al., 2010). Therefore, establishing baseline data on bee forage flora in Northern Balochistan is essential for long-term ecological monitoring and the sustainable management of pollinator services. Despite these benefits, challenges remain. Honey adulteration, lack of quality standards, and limited awareness among consumers and beekeepers often undermine the growth of the honey industry in Pakistan (Kausar et al., 2024). Furthermore, habitat degradation, overgrazing, and deforestation threaten the availability of floral resources in semi-arid landscapes such as Balochistan (Shah et al., 2020). Addressing these challenges requires integrated efforts that combine scientific research, community awareness, and policy support. This study focuses on the melissopalynological analysis of honey samples collected from five districts of Northern Balochistan: Ziarat, Loralai, Khanozai, Quetta, and Muslimbagh. By documenting the diversity of pollen types present in honey and comparing them with the surrounding vegetation, the study aims to provide baseline data on the bee forage flora of the region. The findings are expected to contribute to honey authentication, biodiversity conservation, and the promotion of apiculture as a sustainable livelihood strategy for local communities.

2. MATERIAL AND METHODS

2.1. Sample collection

Plant specimens with floral structures were randomly collected from the study area to ensure reliable identification of pollen types. Each specimen was placed in a separate paper envelope to prevent cross-contamination with pollen from other sources. Fresh honey samples were obtained during multiple field trips from local beekeepers in five districts of Northern Balochistan: Ziarat, Quetta, Loralai, Khanozai, and Muslimbagh. To maintain their natural properties, the samples were stored in the dark at room temperature (21 ± 3 °C) until laboratory analysis. Both unifloral and multifloral honeys were included, specifically collected for melissopalynological investigation (Jaafar et al., 2017). In parallel, a general survey of the study area was conducted to document the available flowering plants, and systematic collection of plant and honey samples was carried out over a four-month period, from May to August.

2.2. Preparation of glycerine jelly.

Glycerin jelly was employed as the mounting medium for acetolyzed pollen grains prepared from honey samples, floral anthers, and pollen loads, following the standard protocol described by Louveaux et al. (1978).

2.3. Reagents

Distilled Water	50ml
Gelatin	35g
Glycerin	35g
Safranine	0.1%
Phenol	few crystals

2.4. Formation of Glycerine jelly

Glycerin jelly was prepared using a modified protocol adapted from Ahmed et al. (2008). In brief, 50 mL of distilled water was heated on a hot plate, and 35 g of gelatin was gradually added at 70–80 °C until a homogenous viscous solution was obtained. The mixture was maintained at this temperature for one hour under continuous stirring. Subsequently, 35 g of glycerin along with a few crystals of phenol were incorporated to enhance stability. To improve contrast during microscopic examination, 0.1% safranin solution was added at one-eighth of the jelly volume. The mixture was gently agitated until a uniform pink coloration developed and was then cooled to room temperature, where it stabilized for later use.

2.5. Preparation of pollen slides from fresh materials

Reference slides were produced from anthers of fully developed flower buds using the acetolysis technique originally outlined by Erdtman (1960) and later refined by Ponnuchamy et al. (2014). Creating a regional pollen reference library was considered essential for reliable identification, as it provided baseline information on the morphological features of the dominant local pollen taxa. This reference set enabled direct comparison with the pollen grains detected in honey samples. To prepare the slides, pollen was gently extracted from anthers and transferred onto clean microscope slides. Lipid residues were removed through an ether–glycerin jelly treatment to improve transparency. The pollen grains were then embedded in glycerin jelly, sealed with a coverslip, and examined under a compound microscope at 40× magnification for comparative analysis.

2.6. Extraction of pollen from honey samples

Pollen analysis was conducted following the standard melissopalynological protocol described by Louveaux et al. (1978). Honey samples were collected from traditional beehives maintained by local beekeepers during the harvesting season (June–September). For each sample, 10 g of honey was dissolved in 30 mL of distilled water and centrifuged at 2,500–3,000 rpm for 10 minutes. The supernatant was carefully decanted, and the residue was re-suspended in 10 mL of distilled water. This suspension was centrifuged again for 5 minutes under the same conditions, after which the sediment containing pollen grains was mounted on a microscope slide. Glycerin jelly was added as a mounting medium to enhance the visibility of the pollen. Observations were made using a compound light microscope at 40× magnification. Pollen grains were identified, counted, classified and their relative frequency was calculated as a percentage of the total pollen count. The frequency classes proposed by Louveaux et al. (1978) were used to distinguish major and minor nectar and pollen sources.

2.7. Identification of pollens from honey

Pollen identification was carried out using reference slides prepared from fresh floral material collected in the study area, in combination with published literature (Erdtman, 1954; Nair, 1970; Gupta & Sharma, 1986). The reference collection served as a baseline for comparative analysis, enabling accurate recognition of pollen types present in the honey samples. Identification was performed to the species level wherever possible; in some cases, generic or family-level classification was applied. The binomial names of taxa were confirmed through cross-checking with both reference palyniferous material and relevant taxonomic literature. The study contributed to a clearer understanding of the major nectar- and pollen-yielding plants in Northern Balochistan and highlighted their potential value for apiculture. A total of 30 bee forage species were identified and are presented in Table 3. Documenting this floral diversity provides useful guidance for beekeepers, as knowledge of key forage species and their seasonal availability is critical for optimizing honey production and developing sustainable beekeeping practices.

3. Results

Microscopic examination of the five honey samples collected from Northern Balochistan revealed 30 distinct pollen types, representing 14 angiosperm families (Fig. 2; Table 3). The majority of samples were multifloral, demonstrating the wide foraging range of honeybees in the region. The most prevalent pollen taxa included *Sonchus oleraceus*, *Peganum harmala*, *Helianthus annuus*, *Malus pumila* and *Punica granatum*, all of which were consistently present across samples. At the family level, *Asteraceae* contributed the highest richness, with eight species such as *Helianthus annuus*, *Sonchus oleraceus*, *Centaurea iberica* and *Taraxacum officinale*. This dominance reflects the ecological importance of *Asteraceae*, the largest plant family in Pakistan, comprising over 650 species across 15 tribes (Qaiser et al., 2025). Other prominent families were *Brassicaceae* (four species), *Fabaceae* (three species), *Rosaceae* (three species) and *Zygophyllaceae* (three species), while the remaining families contributed one or two species each. Life-form analysis revealed that herbs were the predominant contributors to the pollen spectrum (20 species), followed by shrubs (five species), trees (three species), and climbers (two species) (Fig. 3). This distribution underscores the significance of herbaceous flora as primary forage sources for honeybees. Notably, species with prolonged flowering seasons, including *Sonchus oleraceus*, *Rosa beggeriana*, *Malva neglecta*, and *Convolvulus arvensis*, were frequently detected, confirming their importance as dual sources of pollen and nectar throughout the honey production period. The overall diversity and representation of multiple floral sources demonstrate the multifloral character of Northern Balochistan honeys. Local vegetation played a decisive role in shaping the pollen profile, consistent with earlier findings that regional plant diversity facilitates both multifloral and monofloral honey production depending on floral dominance (Webby, 2004; Villanueva-Gutiérrez et al., 2005). These results provide a baseline inventory of dominant bee plants in the region, highlighting their critical contribution to sustaining apiculture and ensuring honey quality.

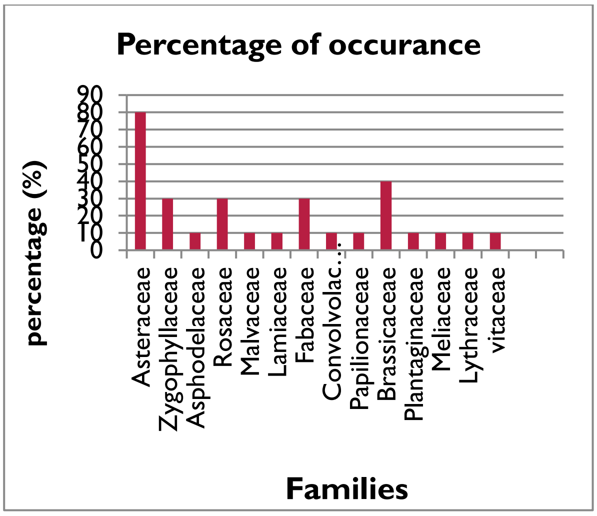


Figure 2: Relative representation of plant families detected in honey samples from Northern Balochistan, illustrating the dominance of Asteraceae and contributions from other key families.

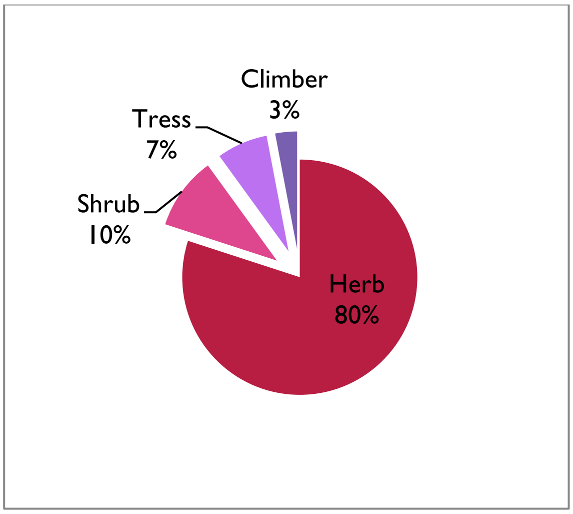


Figure 3: Distribution of botanical life-forms among bee forage plants in Northern Balochistan, presenting the predominance of herbaceous species in honey samples.

Table 1. Palynological investigation of Melliferous flora of Northern Balochistan, Pakistan

S. NO	Plant Species	Family	Habit	Pollen Type	Voucher Name	Location	Time of Collection
1	*Sonchus oleraceus* L.	Asteraceae	Herb	Lophate	SBK201	Loralai,Ziarat,Quetta,Khanozai	May
2	*Taraxacum officinale* L.	Asteraceae	Herb	Tricolporat, Echinat	SBK202	Loralai,Ziarat,Quetta,Khanozai	May
3	*Eremurus stenophyllus* (boiss.& buhse)baker	Asphodelaceae	Herb	Diporate	SBK203	Ziarat	May
4	*Tribulus terrestris* L.	Zygophyllaceae	Herb	Trizonocolporate	SBK204	Quetta	June
5	*Malva neglecta* (Wallr.)	Malvaceae	Herb	Spheroidal, Echinate	SBK205	Quetta	June
6	*Rosa beggeriana* (Schrenk ex Fisch & C.A.Mey)	Rosaceae	Shrub	Trizonocolporate	SBK206	Ziarat	May
7	*Salvia cabulica* (Benth)	Lamiaceae	Shrub	Polycolporate	SBK207	Ziarat, Quetta	May
8	*Medicago sativa* L.	Fabaceae	Herb	Tricolporote, Psilaten	SBK208	Quetta	June
9	*Centaurea iberica* (Trevir.ex Spreng)	Asteraceae	Herb	Trizonocolporate	SBK209	Quetta	June
10	*Acroptilo repens* L.DC.	Asteraceae	Herb	Lophate, Scabrate	SBK210	Quetta	June
11	*Convolvulus arvensis* L.	Convolvolaceae	Climbing Herb	Tricolporate, Granulate	SBK211	Quetta,Ziarat, Khanozai	June
12	*Carthamus oxyacantha* M.Bieb.	Asteraceae	Herb	Echinate, Tricolporate	SBK212	Loralai,Ziarat Quetta,Khanozai	June
13	*Helianthus annuus* L.	Asteraceae	Herb	Spheroidal, Echinate	SBK213	Loralai,Ziarat,Quetta,Khanozai	July

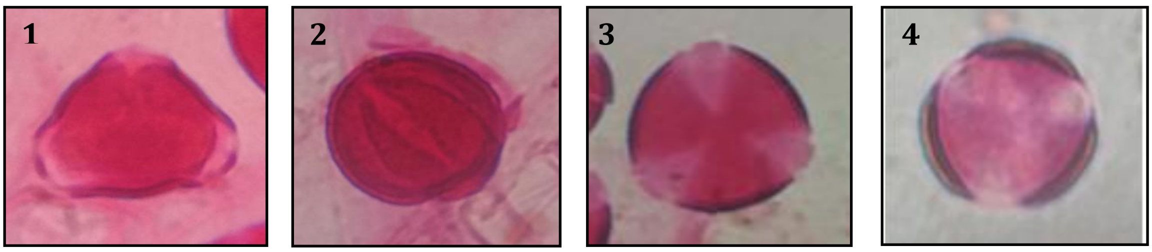
14	*Peganum harmala* L.	Zygophyllaceae	Herb	Trizonocolporate	SBK214	Loralai,Khanozai,Quetta	June
15	*Prunus avium* L.	Rosaceae	Tree	Tetracolporate	SBK215	Loralia,Ziarat,Quetta,Khanozai	April
16	*Astragalus stocksii* Bunge	Papilionaceae	Shrub	Tricolporate, Scabrate	SBK216	Ziarat	April
17	*Malcolmia africana* (L.) R.Br.	Brassicaceae	Herb	Trizonocolporate	SBK217	Ziarat,	May
18	*Zygophyllum fabago* L.	Zygophyllaceae	Herb	Inaperturate	SBK218	Quetta	June
19	*Melilotus indicus* (L.) All.	Fabaceae	Herb	Diporate	SBK219	Ziarat	May
20	*Sisymbrium irio* L.	Brassicaceae	Herb	Tricolporate, Psilate	SBK220	Ziarat,Quetta, Khanozai	May
21	*Cardaria chalepensis* L.	Brassicaceae	Herb	Trizonocolporate	SBK221	Quetta	May
22	*Plantago lanceolata* L.	Plantaginaceae	Herb	Porate, Scabrate	SBK222	Loralai,Quetta	May
23	*Malus pumila* Mill.	Rosaceae	Tree	Trizonocolporate	SBK223	Khanozai,Ziarat,Quetta,Loralia	April
24	Hertia intermidia (Boiss.) Kuntze	Asteraceae	Herb	Trizonocolporate	SBK224	Khanozai	May
25	Conyza canadensis (L.) Cronquist	Asteraceae	Herb	Triporate	SBK225	Quetta	May
26	Descurainia sophia (L.) Webb ex Prantl	Brassicaceae	Herb	Trizonocolporate	SBK226	Ziarat,Khanozai	May
27	*Melia azedarach* L.	Meliaceae	Tree	Tetracolporate Psilate	SBK227	Quetta	April
28	*Sophora mollis* L.	Fabaceae	Shrub	Tricolporate Psilate	SBK228	Ziarat	April
29	*Vitis vinifera* L.	Vitaceae	Vine	Tricolpate Psilate	SBK229	Khanozai	April
30	*Punica granatum* L.	Lythraceae	Shrub	Tricolporote Psilaten	SBK230	Ziarat	April

Table 2. Flowering calendar of honey bee plants species at northern Balochistan, Pakistan.

Scientific name of plant	Plant Family	Duration of flowering time							
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Astragalus stocksii Bunge.	Papilionaceae		**	**					
Acroptilo repens L.DC.	Asteraceae		**	**	**				
Centaurea iberica (Trevir.ex Spreng)	Asteraceae			**	**				
Convolvulus arvensis L.	Convolvolaceae	**	**	**	**	**	**	**	**
Carthamus oxyacantha M.Bieb.	Asteraceae		**	**	**				
Conyza Canadensis (L.) Cronquist	Asteraceae			**	**	**	**	**	
Descurainia Sophia (L.) Web ex Prantl	Brassicaceae	**	**	**					
Eremurus stenophyllus (boiss & buhse) baker	Asphodelaceae			**	**	**			
Hertia intermidia (Boiss.) Kuntze	Asteraceae	**	**	**	**	**			
Helianthus annuus L.	Asteraceae	**	**	**	**	**	**	**	
Cardaria chalepensis L.	Brassicaceae	**	**	**					
Malva neglecta (Wallr.)	Malvaceae	**	**	**	**	**	**	**	**
Medicago sativa L.	Fabaceae	**	**	**	**	**	**	**	
Malcolmia Africana (L.) R.Br.	Brassicaceae	**	**	**					
Melilotus indicus (L.) All.	Fabaceae	**	**	**					
Malus pumila Mill.	Rosaceae	Mid Feb	To	Mid Mar					
Melia azedarach L	Meliaceae	**	**						
Punica granatum L.	Lythraceae	**	**	**					

Plantago lanceolata L.	Plantaginaceae			**	**	**			
Prunus avium L.	Rosaceae	**							
Peganum harmala L.	Zygophyllaceae	**	**	**	**				
Rosa beggeriana (Schrenk ex Fisch &C.A.Mey)	Rosaceae	**	**	**	**	**	**	**	**
Sonchus oleraceus L.	Asteraceae	**	**	**	**	**	**	**	**
Salvia cabulica (Benth)	Lamiaceae		**	**	**	**	**		
Sisymbrium irio L.	Brassicaceae		**	**	**	**	**	**	
Sophora mollis L.	Fabaceae	**	**						
Tribulus terrestris L.	Zygophyllaceae		**	**	**	**	**	**	
Taraxacum officinale L.	Asteraceae	**	**						
Vitis vinifera L.	Vitaceae			**	**	**			
Zygophyllum fabago L.	Zygophyllaceae			**	**	**	**	**	





5 6 7 8

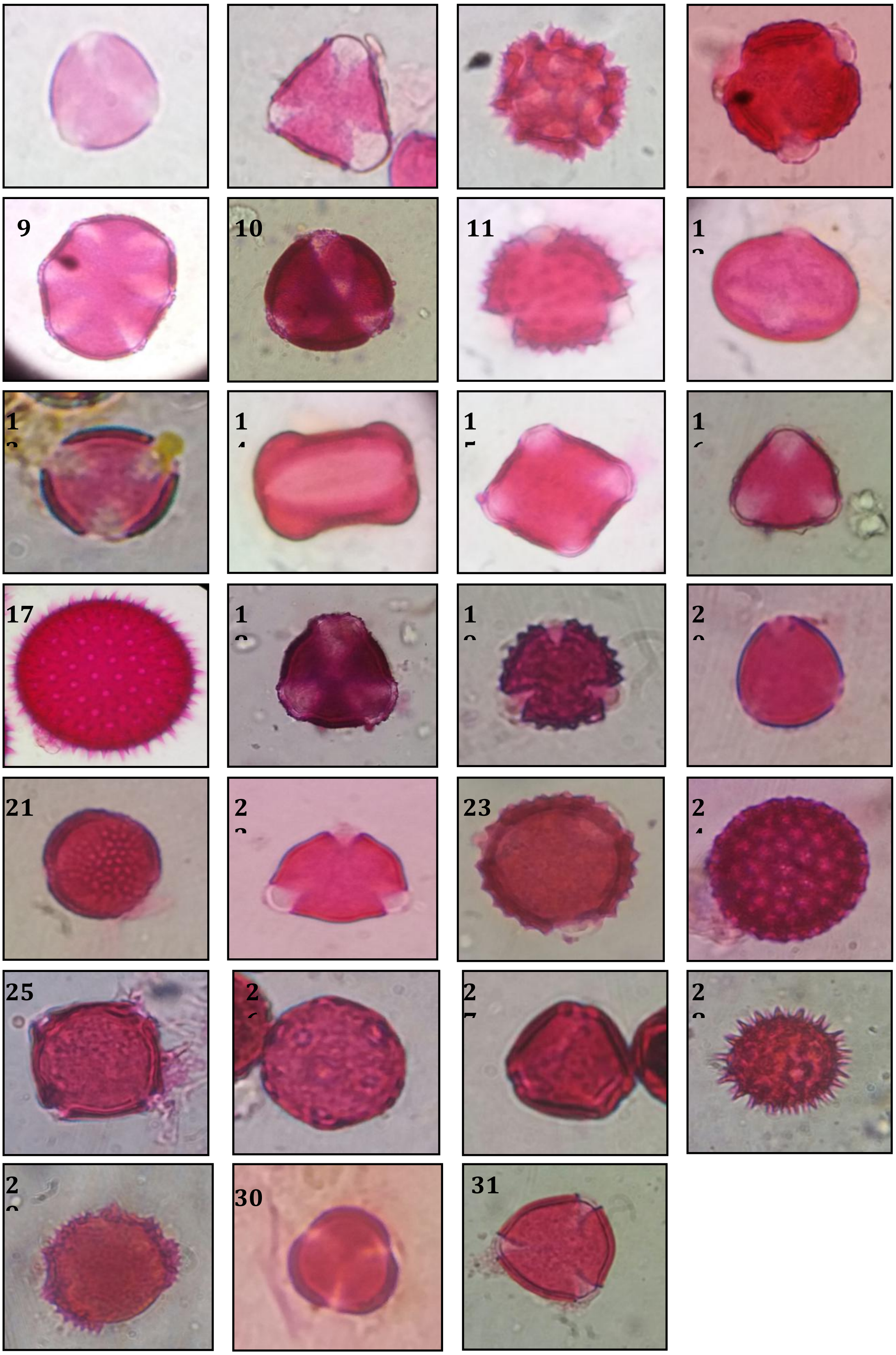


Fig. 1: Microphotographs of pollen grains found in the honey samples

3. DISCUSSION:

The present melissopalynological study provides valuable insights into the botanical origins of honey in northern Balochistan and highlights the close ecological relationships between honeybees and their floral resources. A total of 30 pollen taxa from 14 families were identified, indicating the broad spectrum of bee forage available in this semi-arid region. Among these, Asteraceae, Brassicaceae, Fabaceae, Rosaceae, and Zygophyllaceae emerged as dominant families. The prevalence of *Asteraceae* is consistent with its ecological abundance and taxonomic dominance in Pakistan, where it is represented by more than 650 species across diverse habitats (Qaiser et al., 2025). Similar findings have been reported in palynological studies of honey from South Asia and other subtropical regions, where *Asteraceae* and *Fabaceae* consistently contribute the majority of pollen spectra (Noor et al., 2016; Villanueva-Gutiérrez et al., 2009). One of the most striking outcomes of this study was

the multifloral character of the majority of honey samples, with pollen contributions from both wild and cultivated species. Frequent pollen types included *Sonchus oleraceus*, *Peganum harmala*, *Helianthus annuus*, *Malus pumila*, and *Punica granatum*, all of which reflect the diverse vegetation structure of northern Balochistan. Multifloral honeys are highly valued due to their broad nutritional composition and bioactive potential, as they combine pollen from multiple botanical families (Tulu, 2023). The simultaneous occurrence of pollen from wild species (e.g., *Convolvulus arvensis* and *Rosa beggeriana*) and cultivated crops (e.g., *Helianthus annuus* and *Brassica spp.*) illustrates the adaptive foraging behavior of honeybees. Comparable patterns have been observed in India, where bees integrate pollen from seasonal crops and indigenous flora to meet colony nutritional demands (Alam et al., 2025; Haldhar et al., 2021). The dominance of crop pollen, particularly from *Brassicaceae* and *Helianthus annuus*, further underscores the integration of apiculture within agroecosystems. Mass-flowering crops provide abundant nectar and pollen resources during short flowering windows, which explains their prominence in honey spectra from Pakistan and neighboring regions (Alam et al., 2025; Kumar et al., 2018). However, overreliance on monoculture crops may reduce the diversity of bee diets and compromise colony health (Di Pasquale et al., 2013). In contrast, multifloral honeys derived from diverse wild and cultivated sources are associated with superior antioxidant properties and higher nutritional quality (Escuredo et al., 2023). Therefore, ensuring the availability of diverse melliferous plants is essential for sustainable honey production in Balochistan. Another important implication of this study is its relevance for honey authentication and quality control. Melissopalynology provides a botanical "fingerprint" of honey, which is critical for verifying floral sources, determining geographical origin, and detecting adulteration (Louveaux et al., 1978; Anklam, 1998). This is especially significant in Pakistan, where concerns over adulterated honey remain widespread. Our results demonstrate that pollen analysis can reliably distinguish multifloral from monofloral honeys, thereby contributing to certification and market competitiveness. Studies in Nigeria and Ethiopia have emphasized the role of pollen analysis in verifying honey authenticity, supporting traceability, and promoting export quality (Essien et al., 2023; Hussein & Seid, 2024). These findings also highlight the importance of seasonal and ecological dynamics in shaping honey composition. Species with extended flowering periods, such as *Sonchus oleraceus*, *Rosa beggeriana*, and *Convolvulus arvensis*, were frequently represented, indicating that long-flowering taxa provide critical continuous forage. This agrees with global studies demonstrating that prolonged-bloom species enhance the stability of honeybee diets across seasons (Odoux et al., 2012). Thus, conserving native melliferous flora with staggered flowering schedules could strengthen apiculture resilience in semi-arid ecosystems like northern Balochistan. Comparisons with other regional studies reinforce the reliability of our results. Bibi et al. (2008) found that honeys from northern Pakistan were dominated by *Asteraceae* and *Brassicaceae*, while Ahmad et al. (2023) reported the strong presence of *Fabaceae* and *Lamiaceae* in honeys from Khyber Pakhtunkhwa. Similarly, international studies from Mexico and Spain revealed the consistent dominance of *Asteraceae* and *Fabaceae*, suggesting these families are globally significant melliferous taxa (Villanueva-Gutiérrez et al., 2005; Pérez-Arquillué et al., 1995). Such consistencies demonstrate the universality of honeybee foraging preferences for resource-rich taxa. This study confirms that honeybees in northern Balochistan utilize a wide range of floral resources, with a strong representation of both wild and cultivated plants. The predominance of multifloral honeys highlights the ecological richness of the region, while the detection of crop pollen underlines the integration of beekeeping with agricultural practices. These findings emphasize the dual importance of melissopalynology for both ecological research and honey quality assurance. Protecting native melliferous flora, promoting diversified agricultural landscapes, and incorporating pollen analysis into honey certification protocols are essential strategies for strengthening apiculture in Pakistan.

4. CONCLUSIONS

This Melissopalynological study provides the first systematic documentation of the botanical spectrum of honeys from northern Balochistan, Pakistan, offering both scientific and applied contributions to apiculture in the region. Microscopic analysis of five honey samples identified 30 pollen taxa representing 14 families, with a clear predominance of Asteraceae, Brassicaceae, Fabaceae, Rosaceae, and Zygophyllaceae. The frequent occurrence of *Sonchus oleraceus*, *Peganum harmala*, *Helianthus annuus*, *Malus pumila*, and *Punica granatum* demonstrates the reliance of honeybees on both wild and cultivated flora, reflecting the ecological diversity of the study area. These results confirmed that multiflorality is the characteristic feature of most honeys from northern Balochistan, though traces of monofloral origins were also detected. Multifloral honeys are not only ecologically significant but also nutritionally valuable, as they integrate diverse pollen sources with potential health-promoting bioactive compounds. Importantly, the predominance of herbaceous species and long-flowering plants highlights their role in sustaining colonies across extended periods, ensuring consistent nectar and pollen availability in a semi-arid landscape. Beyond ecological insights, this study highlights the applied value of melissopalynology in honey authentication, quality assurance, and traceability. By linking pollen spectra to specific floral and geographical origins, this approach enhances consumer confidence and strengthens the marketability of Pakistani honeys at both national and international levels. Overall, these findings establish a baseline reference for the floral origins of honeys in northern Balochistan, emphasizing the need to conserve native melliferous flora and maintain diversified agroecosystems to support sustainable beekeeping. By integrating pollen analysis into routine apicultural practices, Pakistan can advance toward scientifically informed honey production, improved quality standards, and greater resilience of its apiculture industry

REFERENCES

[1] Adgaba, N., Al-Ghamdi, A., Tadesse, Y., Getachew, A., Awad, A. M., Ansari, M. J., … Alqarni, A. S. (2017). Nectar secretion dynamics and honey production potentials of some major honey plants in Saudi Arabia. Saudi Journal of Biological Sciences, 24(1), 180–191. https://doi.org/10.1016/j.sjbs.2016.02.010

[2] Al-Khalifa, A. S., & Al-Arify, I. A. (1999). Physicochemical characteristics and pollen spectrum of some Saudi honeys. Food Chemistry, 67(1), 21–25. https://doi.org/10.1016/S0308-8146(99)00105-3

[3] Gyawali, A. (2025). Evaluating the status and potential of honey production in Nepal. Insight from pollen analysis and beekeeping practices.

[4] Junaid, M., & Khan, S. (2020). Problems and Prospects of Honey Value chain in Peshawar, Khyber

Pakhtunkhwa: A Grounded Theory Analysis. Journal of Managerial Sciences, 14.

[5] Kausar, G., Yousaf, A. I., Afzal, U., Tariq, W., Ambreen, M., Gull, Z., ... & Khan, S. U. (2024). Quality Assessment and Authentication of Raw Honey-Available at Local Markets of Punjab. Indus Journal of Bioscience Research, 2(02), 1038-1046.

[6] Khan, K., Ahmad, M., Ali, M., Zafar, M., Haq, I. U., Papini, A., ... & Malik, K. (2022). Melissopalynological and biochemical profile of honeybee (Apis mellifera L.) flora in Southern Khyber Pakhtunkhwa, Pakistan. Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology, 156(5), 1177-1186.

[7] Louveaux, J., Maurizio, A., & Vorwohl, G. (1978). Methods of melissopalynology. Bee World, 59(4), 139–157. https://doi.org/10.1080/0005772X.1978.11097714

[8] Persano Oddo, L., & Piro, R. (2004). Main European unifloral honeys: Descriptive sheets. Apidologie, 35(S1), S38–S81. https://doi.org/10.1051/apido:2004049

[9] Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: Trends, impacts and drivers. Trends in Ecology & Evolution, 25(6), 345–353. https://doi.org/10.1016/j.tree.2010.01.007

[10] Shah, F. A., Akbar, W., Ullah, H., & Ullah, R. (2020). Floral resources and honeybee foraging in Balochistan, Pakistan. Journal of Entomology and Zoology Studies, 8(1), 350–356.

[11] Song, X. Y., Yao, Y. F., & Yang, W. D. (2012). Pollen analysis of natural honeys from the central region of Shanxi, North China. PloS one, 7(11), e49545.

[12] Qaiser, M., Perveen, A., Alam, J., Ali, H., & Abid, R. (2025). Asteraceae in Pakistan and Kashmir with special emphasis on distribution pattern and endemism. Genetic Resources and Crop Evolution, 1-30.

[13] Anklam, E. (1998). A review of the analytical methods to determine the geographical and botanical origin of honey. Food Chemistry, 63(4), 549–562. https://doi.org/10.1016/S0308-8146(98)00057-0

[14] Alam, W., Khan, Q. A., Ali, H. W., Kamal, D., Bibi, I., & Rizwan, M. (2025). Identification of the Melissopalynological Flora of Northern Punjab using Honey Bee Samples. Indus Journal of Bioscience Research, 3(5), 872-882.

[15] Escuredo, O., Rodríguez-Flores, M. S., Míguez, M., & Seijo, M. C. (2023). Multivariate statistical approach for the discrimination of honey Samples from Galicia (NW Spain) using physicochemical and pollen parameters. Foods, 12(7), 1493.

[16] Di Pasquale, G., Salignon, M., Le Conte, Y., Belzunces, L. P., Decourtye, A., Kretzschmar, A., ... & Alaux, C. (2013). Influence of pollen nutrition on honey bee health: Do pollen quality and diversity matter? PLoS ONE, 8(8), e72016. https://doi.org/10.1371/journal.pone.0072016

[17] Haldhar, S. M., Nidhi, C. N., Singh, K. I., & Devi, A. S. (2021). Honeybees diversity, pollination, entrepreneurship and beekeeping scenario in NEH region of India. Journal of Agriculture and Ecology, 12, 27-43.

[18] Tulu, D., Aleme, M., Mengistu, G., Bogale, A., Bezabeh, A., & Mendesil, E. (2023). Melissopalynological analysis and floral spectra of Apis mellifera scutellata Lepeletier bees in different agroecologies of southwest Ethiopia. Heliyon, 9(5).

[19] Essien, B. C., & Olaniyi, B. O. (2023). Pollen analysis and physicochemical characterization of honey samples from owo local government area, Ondo State, Nigeria. Global Research in Environment and Sustainability, 1(7), 66-79.

[20] Louveaux, J., Maurizio, A., & Vorwohl, G. (1978). Methods of melissopalynology. Bee World, 59(4), 139–157. https://doi.org/10.1080/0005772X.1978.11097714

[21] Bibi, S., Husain, S. Z., & Malik, R. N. (2008). Pollen analysis and heavy metals detection in honey samples from seven selected countries. Pak J Bot, 40(2), 507-516.

[22] Odoux, J. F., Feuillet, D., Aupinel, P., Loublier, Y., Tasei, J. N., & Mateescu, C. (2012). Territorial biodiversity and consequences on physico-chemical characteristics of honey. Journal of Apicultural Research, 51(4), 1–10. https://doi.org/10.3896/IBRA.1.51.4.11

[23] Pérez-Arquillué, C., Conchello, P., Arino, A., Juan, T., & Herrera, A. (1995). Physicochemical attributes and pollen spectrum of Spanish honeys. Food Chemistry, 54(2), 167–172. https://doi.org/10.1016/0308-8146(95)00011-R

[24] Ahmad, S., Zafar, M., Ahmad, M., Zafar, S., Arfan, M., Khan, A. M., ... & Majeed, S. (2023). Melissopalynological studies of autumn honey samples from khyber pakhtunkhwa, pakistan. J Anim Plant Sci-JAPS, 33(5), 1184-1192.

[25] Jamil Noor, M., Ahmad, M., Ashraf, M. A., Zafar, M., & Sultana, S. (2016). A review of the pollen analysis of South Asian honey to identify the bee floras of the region. Palynology, 40(1), 54-65.

[26] Villanueva-G, R., Roubik, D. W., & Colli-Ucán, W. (2005). Extinction of Melipona beecheii and traditional beekeeping in the Yucatán peninsula. Bee World, 86(2), 35-41.

[27] Alam, W., Khan, Q. A., Ali, H. W., Kamal, D., Bibi, I., & Rizwan, M. (2025). Identification of the Melissopalynological Flora of Northern Punjab using Honey Bee Samples. Indus Journal of Bioscience Research, 3(5), 872-882.