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Melissopalynological studies of western part of Almora District, Uttarakhand

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ABSTRACT

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The study of pollen contents has been carried out from the honey samples procured from the western zone of Almora District, Uttarakhand. A total of ten honey samples were collected of which four were unifloral and two bifloral. *Sapindus rarak*, *Brassica campestris*, *Salmalia malabaricum*, *Caesalpinia pulcherrima*, *Coriandrum sativum, Syzygium cumini* and *Mimosa pudica* are the dominant pollen types observed in the samples. Besides, the other reliable nectar sources were also identified from the study area. The numerous pollen types and their diversity showed that bees travel considerable distance for collecting nectar for honey production.

Key–words—Melissopalynology, Squeezed honey, Nectar source, Almora, Uttarakhand.

जिला अल्मोड़ा, उत्तराखंड के पश्चिमी भाग के मेलिस्सोपरागाणविक अध्ययन

स्वाति दीक्षित, एस.के. बसुमतारी, हुकम सिंह व एस.के. बेरा

सारांश

जिला अल्मोड़ा, उत्तराखंड के पश्चिमी मंडल से प्राप्त किए गए मधु नमूनों के पराग अंतर्वस्तुओं का अध्ययन किया गया है। कुल मिलाकर दस नमूने संगृहीत किए गए थे जिनमें से चार एकलपुष्पी व दो द्विपुष्पी थे। नमूनों में प्रेक्षित किए गए *सैपिंडस रेरक, ब्रैसिका कैंपेस्टरिस, सल्मालिया मालाबेरिकम, कैसालपिनिया पल्चेर्रिमा, कॉरिएंड्रम सेटिवम, सायज़ीजियम क्युमिनि* एवं *मिमोसा पुडिका* प्रभावी पराग प्रकार हैं। जबकि, अध्ययन किए गए क्षेत्र से अन्य विश्वसनीय मकरंद स्रोत भी अभिनिर्धारित किए गए। बहुत-से पराग प्रकारों एवं उनकी विविधता ने दर्शाया कि मधु उत्पादन हेतु मकरंद संगृहीत करने के लिए मधुमक्खियां अच्छी-खासी दूरी तय करती हैं।

संकेत-शब्द—मेलिस्सोपरागाणुविज्ञान, निष्पीडित शहद, मकरंद स्रोत, अल्मोड़ा, उत्तराखंड।

INTRODUCTION

Melissopalynological studies supplemented with critical field studies of phenology and floral biology provides reliable information of floral types highlight various types of unifloral and bifloral honeys that can be obtained in different seasons. It helps the beekeepers in the proper management of bee colonies during dearth periods. In the growth and development of honey bees, nectar is the source of carbohydrates, whereas proteins are provided by the pollen (Lin *et al*., 1993). Because of varied nature of floral component, their associations and local spread, the pollen spectrum of honey is also an expression of its geographical origin (Ramanujam & Khatija, 1990).

The palynology of Indian honey has been described by several pioneer workers time to time (Sen & Banerjee, 1956; Mittre, 1958; Nair, 1964; Sharma & Nair, 1965; Suryanarayana & Thakar, 1966; Chaturvedi, 1976; Mondal & Mitra, 1980; Nair, 1985; Shah & Shah, 1989; Malakar *et al*., 1995; Kalpana & Ramanujam, 1996; Kumar, 2000; Jana *et al*., 2000; Bera *et al*., 2009b; Chauhan & Singh, 2010; Chauhan & Trivedi, 2011; Singh & Kar, 2011; Dixit *et al*., 2012). Beekeeping endeavour

in Uttarakhand has been taken up on a modest commercial scale by beekeepers in some remote districts. Almora District has great potential of beekeeping, but palynological information's are very scanty. The reliable information on the bee plants, types of honey, nectar flow and dearth periods in this district are highly limited and inadequate except few scattered publications from Pauri Garhwal (Gaur & Nanwani, 1989), Kangra (Sharma, 1970) and Chamba District (Attri, 2010).

Almora District lies between 29°30'N to 30°20'N latitudes and 79°30' E to 80°20'E longitudes (Fig. 1). It is located in the central part of Kumaun region of Uttarakhand (India). The study area covering of around 3090 sq km with its limit of 46 km in north–south and 86 km in east–west. The Ramganga, Kosi, Gagas and Sarju are the major drainage system of the region. The area exhibits great variety of regions, extending from tropical moist deciduous forest to moist mixed coniferous forest. The mountainous tracts of the whole district have varying geomorphology which contributes to a great extent for the variation of the climatic conditions. There are three seasons in a year covering summer, rainy and winter. In summer season, May and June are the hottest months. During this period the temperature rises from 12 to 28°C. In winter season, January being the coldest month, when the minimum temperature goes down to 2°C, it may goes to freezing point or even below. The rainy season is characterized by heavy rainfall and average rainfall is 1,152 mm. In general monsoon breaks in June and area receives upto 90% of precipitation in July and August, while November is the driest month. Thunder storms, often accompanied by hailstorms which are fairly frequent in the area. This climatic condition favours buffer plant growth and the vegetation attains its maximum development. The soil and rock type varies from place to place and plays an important role in the vegetative growth. The soil texture ranges from sandy loam to clayey loam (Kumari *et al*., 2011).

FLORA AND FAUNA

Flora and fauna is an inseparable part of Almora District. The region of Almora District is immensely rich with four thousand species of plants (Gaur & Bartwal, 1995) and a natural sanctuary of variety of animals (Binsar Wildlife Sanctuary). This area has remarkable diversity in its natural vegetation by virtue of its being at a great range of elevations. In addition to its climatic variations, particularly in temperature and precipitation associated with the alignment and altitudes of ranges and nature of valleys, determine the

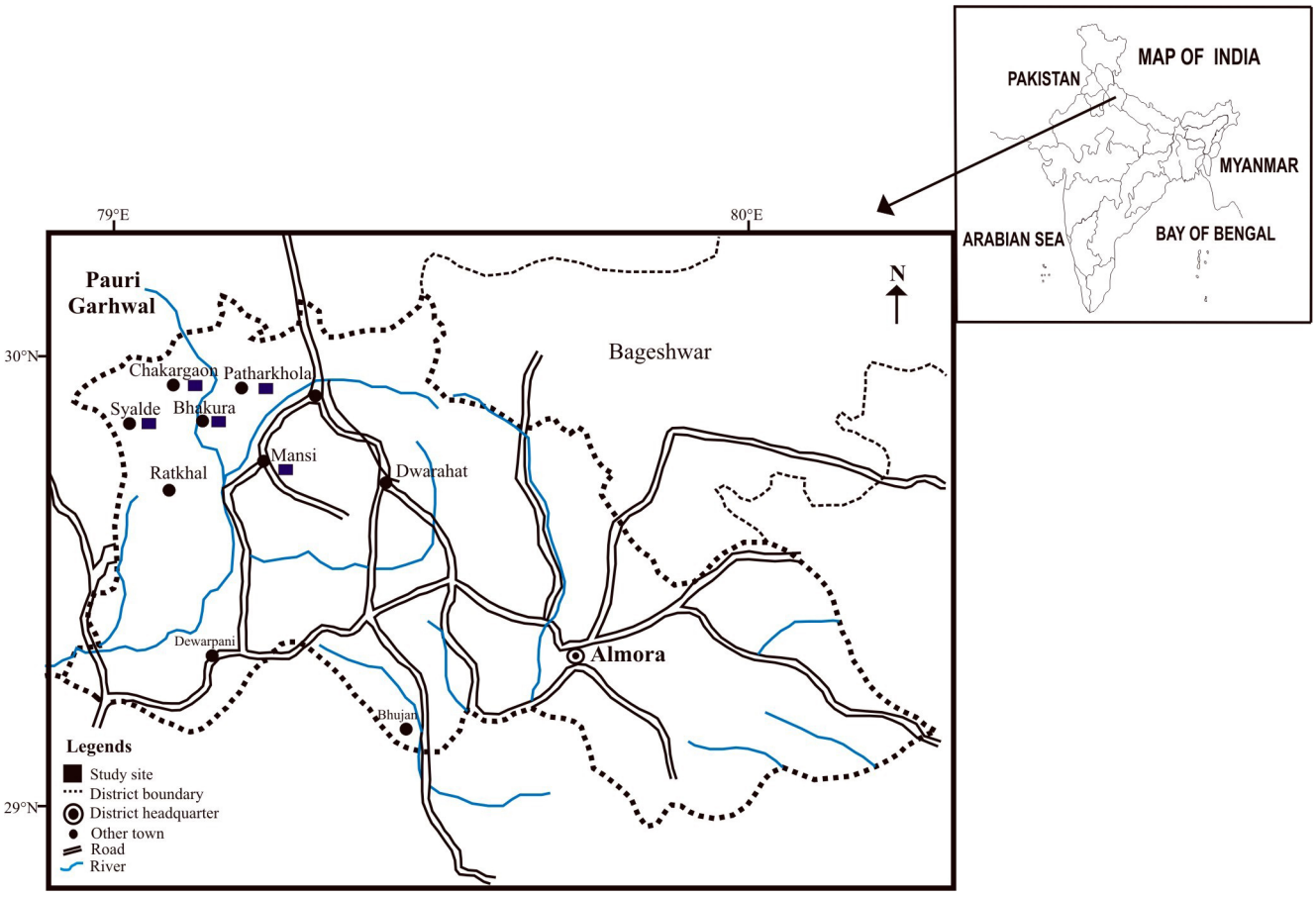

Fig. 1—Location map showing study areas.

Zone	Altitude (m)	Plant community	Plant Species
Sub Tropical	300–1000	Sal	*Shorea robusta*, *Semecarpus anacardium*, *Adina cordifolia*, *Bauhinia vahlii*, *Madhuca longifolia*, etc.
	1200–1800	Pine	*Pinus roxburghii*, *Pyrus pashia*, *Dalbergia sericia*, *Caseana elliptica*, *Syzygium cumini*, etc.
	800–1500	Vijaysar	*Pterocarpus marsupium*, *Engelhardtia spiicata Sapium onsigne*, *Dalbergia sissoo*, *Syzygium cumini*, etc.
	500–1200	Ramal	*Macaranga pustulata, Mallotus philippinensis, Toona serrata,* etc.
	300–1500	Faliyal Oak	*Quercus gloca, Pyrus pashia*, *Emblica officinalis*, *Callicarpa arborea*, *Rubus ellipticus*, etc.
	1500–1800	Chair Pine and Bany Oak	*Pinus roxburghii, Myrica esculenta, Rhododendron arboreum, Pyrus pashia*, etc.
Sub Temperate	1800–2200	Deodar	*Cedrus deodara, Rubus ellipticus, Berberis asiatica,* etc.
	1400–2200	Utis	*Alnus nepalensis, Rubus ellipticus, Betula alnoides*, etc.
	2000–2500	Horse chestnut	*Esculus indica, Betula alnoides, Juglans regia, Litsea umbrosa*, etc.
	2100–2800	Kal	*Pinus wallichiana,* etc.
	1800–2200	Banj Oak	*Quercus leucotriochophora, Myrica esculenta, Betula alnoides, Pyrus pashia*, etc.
	2000–2500	Rianj Oak	*Quercus lanuginose, Myrica esculenta, Betula alnoides, Pyrus pashia*, etc.
	2200–2700	Tilonj Oak	*Quercus floribunda, Rhododendron arboreum, Lyonia ovalifolia, Litsea umbrosa*, etc.
Sub Alpine	2800–3800		*Betula utilis, Abies pindrow, A. spectabilis, Rhododendron campanulatum*, *Quercus semecarpifolia*, etc.
Alpine	3800–5000		*Rhododendron arboreum*, *Anemone obtusiloba*, *Caltha palustris*, *Fragaria nubicola*, *Rosa macrophylla*, *Impatiens sulcata*, etc.

Fig. 2—The major plant community and species of each vegetation zone growing in Almora District.

altitudinal growth and variety of vegetation. The flora of this region can be classified into four groups, i.e. sub tropical, sub temperate, sub alpine and alpine vegetation. The major plant community and plant species of each vegetation zone are given in Fig. 2.

The sub–tropical forest zone lies between an altitude of 300 and 1800 meters and Sal, Pine, Vijaysar, Ramal, Faliyal Oak, Chair Pine and Bany Oak are the major forest communities of this zone. The Sub–temperate forest zone are generally found in between 1800 to 2800 meters altitude and Deodar, Utis, Horse Chestnut, Kal, Banj Oak, Rianj Oak and Tilonj Oak are the main forest communities of this zone. The Sub Alpine Forest Community is found from 2800 to 3800 meters altitude and *Betula utilis*, *Abies pindrow*, *A. spectabilis*, *Rhododendron campanulatum* and *Quercus semecarpifolia*, are the main species of this community. The Alpine is the most interior community of this region lies between 3800 and 5000 meters altitude. Less shrubs and grassy meadows fall under this community.

MATERIAL AND METHODS

The honey samples measuring 50 ml each have been procured from reserve forests of five different blocks of Almora District during winter and summer season. In each block two samples were collected. During May to July, honey samples were mainly collected from Chakargaon, Syalde and Patharkhola area and during December to January, the same has been procured from Bhakura and Mansi area. The methodology recommended by International Commission for Bee Botany (Louveaux *et al*., 1978) and conventional acetolysis method (Erdtman, 1953) were employed for the recovery and analysis of pollen content from honey samples. The pollen types were placed under three major frequency classes

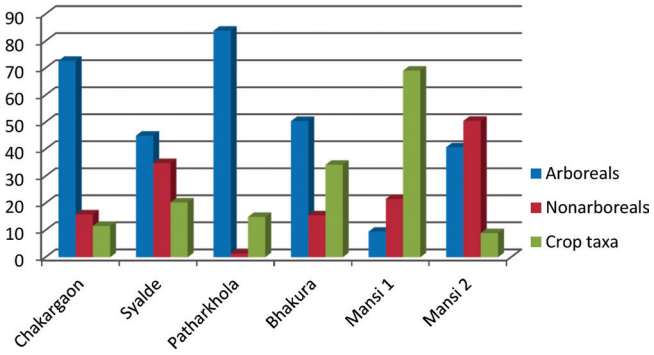

Fig. 3—Pollen spectra from honey of Almora District, Uttarakhand.

namely arboreals, non arboreals and crop taxa for making honey pollen spectra (Fig. 3). Pollen grains in the honey were identified with the help of reference pollen slides available at BSIP–Herbarium and the pollen photographs accessible in the published literatures (Bera *et al*., 2009a, Chauhan & Bera, 1990; Nair, 1990). Honey samples were categorized as unifloral and bifloral according to the predominance of pollen types. Fungal remains and other varia are not included in the pollen sum. Microphotographs were taken by Olympus– BX 61 Microscope with DP–25 camera (Pl. I). Detail list of pollen taxa recovered from each honey sample is given in Fig. 4.

OBSERVATION AND CONCLUSION

The qualitative and quantitative analysis of ten squeezed honey samples, two each from five areas was conducted out of which, six were productive and pollen analytical data of each area is discussed separately below.

Chakargaon area—Out of two samples procured, only one is productive and proved to be bifloral as evidenced by two dominating taxa namely *Sapindus rarak* (14.87%) and *Salmalia malabaricum* (14.26%) attaining almost same frequency. Other important pollen types rankwise are *Brassica campestris* (6.98%), *Coriandrum sativum* (4.56%), *Aegle marmelos* (4.20%), *Melia azedarach* (3.80%), *Caesalpinia pulcherrima* and *Ricinus communis* (3.36% each), *Butea monosperma* (3.28%), *Carissa opaca* (3.10%), *Cassia fistula* (2.98%), *Syzygium cumini* (2.80%), *Mimosa pudica* (2.76%), *Madhuca longifolia* (2.11%) and *Elaeocarpus rugosus* (2.00%). Whereas, other taxa are encountered in lower values including *Celosia argentea* (1.87%), Cyperaceae (1.78%), *Pinus* sp. (1.56%), *Adina cordifolia* (1.53%), *Ilex excelsa* (1.46%), *Acacia catechu* (1.45%), *Symplocos racemosa* and *Litsea salicifolia* (1.40% each), *Juglans regia* (1.26%), Poaceae (1.24%), *Ligustrum indicum* and *Morus alba* (1.23% each) and *Lagerstroemia parviflora* (1.20%) respectively. Rest of the taxa are observed in sporadic values like *Citrus auruntium, Caltha palustris, Rubus ellipticus, Areca catechu,* Acanthaceae, Anacardiaceae and Asteraceae.

Syalde area—In this reserve, out of two samples, one is productive and proved to be bifloral as evidenced by two dominating taxa including *Caesalpinia pulcherrima* (19.65%) and *Brassica campestris* (18.59%) followed by *Mimosa pudica* (13.44%). Other important pollen types rankwise are *Ricinus communis* (4.56%), *Syzygium cumini* (3.56%), Asteraceae (3.45%), Poaceae (2.90%), Anacardiaceae and *Adina*

Scientific name and family	Sample location of honey along with nature					
	Chakargaon (Bifloral) 1 sample	**Syalde (Bifloral)** 1 sample	**Patharkhola (Unifloral)** 1 sample	**Bhakura (Unifloral)** 1 sample	**Mansi (Unifloral)** 2 samples	
Salmalia malabaricum (Bombacaceae)	**14.87%**	1.24%	1.20%	1.87%	–	–
Sapindus rarak (Sapindaceae)	**14.26%**	1.43%	1.32%	–	–	–
Aegle marmelos (Rutaceae)	4.20%	2.45%	1.54%	3.45%	–	–
Juglans regia (Juglandaceae)	1.26%	1.65%	0.78%	2.34%	–	–
Elaeocarpus rugosus (Elaeocarpaceae)	2.00%	1.76%	2.13%	2.67%	–	1.34%
Ilex excelsa (Aquifoliaceae)	1.46%	1.98%	1.89%	1.34%	–	2.65%
Symplocos racemosa (Symplocaceae)	1.40%	1.87%	1.90%	–	–	2.10%
Adina cordifolia (Rubiaceae)	1.53%	2.56%	2.34%	–	–	–
Syzygium cumini (Myrtaceae)	2.80%	3.56%	**60.45%**	2.56%	–	10.45%
Caesalpinia pulcherrima (Caesalpiniaceae)	3.36%	**19.65%**	–	4.34%	–	–

Carissa opaca (Apocynaceae)	3.10%	–	3.25%	–	–	–
Melia azedarach (Meliaceae)	3.80%	–	2.43%	3.60%	–	–
Madhuca longifolia (Sapotaceae)	2.11%	1.45%	–	1.84%	1.00%	3.45%
Lagerstroemia speciosa (Lythraceae)	1.20%	–	–	10.67%	–	–
Litsea umbrosa (Lauraceae)	1.40%	–	–	–	–	–
Butea monosperma (Papilionaceae)	3.28%	–	–	–	–	6.54%
Cassia fistula (Caesalpiniaceae)	2.98%	–	–	–	–	7.98%
Morus alba (Moraceae)	1.23%	–	–	–	–	1.23%
Mimosa pudica (Mimosaceae)	2.76%	13.44%	–	–	–	**45.89%**
Citrus aurantium (Rutaceae)	0.56%	–	–	–	–	–
Caltha palustris (Ranunculaceae)	0.76%	–	–	1.90%	–	–
Rubus ellipticus (Rosaceae)	0.87%	–	–	–	–	–
Arecaceae	0.59%	2.12%	–	2.43%	–	–
Acacia catechu (Mimosaceae)	1.45%	–	–	2.89%	4.50%	3.14%
Albizia lebbeck (Mimosaceae)	–	–	–	1.50%	–	–
Jasminum officinale (Oleaceae)	–	–	–	2.87%	–	–
Ligustrum indicum (Oleaceae)	1.23%	–	–	2.67%	–	–
Solanum erianthum (Solanaceae)	–	–	–	1.89%	–	–
Ricinus communis (Euphorbiaceae)	3.36%	4.56%	–	2.75%	–	–
Mallotus philippensis (Euphorbiaceae)	0.78%	–	–	1.56%	–	–
Celtis australis (Cannabaceae)	–	2.35%	–	1.84%	–	–
Coriandrum sativum (Apiaceae)	4.56%	1.65%	4.56%	**30.56%**	5.49%	1.23%
Brassica campestris (Brassicaceae)	6.98%	**18.59%**	14.87%	9.34%	**65.67%**	8.88%
Acanthaceae	0.67%	1.78%	–	–	2.34%	–
Anacardiaceae	0.98%	2.56%	–	–	–	–
Asteraceae	0.76%	3.45%	–	–	3.56%	1.67%
Malvaceae	–	–	–	1.67%	4.23%	1.67%
Rubiaceae	–	0.00%	1.34%	–	4.34%	–
Poaceae	1.24%	2.90%	–	–	2.87%	1.78%
Amaranthaceae	1.87%	1.34%	–	1.45%	1.65%	–
Cyperaceae	1.78%	1.45%	–	–	2.90%	–
Quercus sp. (Fagaceae)	1.00%	0.98%	–	–	–	–
Pinus sp. (Pinaceae)	1.56%	1.23%	–	–	–	–
Betula utilis (Betulaceae)	–	2.00%	–	–	1.45%	–
Myrica sapida (Myricaceae)	–	–	–	–	–	–

Fig. 4—Showing honey pollen frequency recovered from reserve forests of Almora District.

cordifolia (2.56% each), *Aegle marmelos* (2.45%), *Celtis argentea* (2.35%), Arecaceae (2.12%), *Betula* sp. (2.00%). *Ilex excelsa* (1.98%), *Symplocos racemosa* (1.87%), Acanthaceae (1.78%), *Elaeocarpus rugosus* (1.76%), *Juglans regia* and *Coriandrum sativum* (1.65% each), *Madhuca longifolia* and Cyperaceae (1.45% each), *Sapindus rarak* (1.43%), Amaranthaceae (1.34%), *Salmalia malabaricum* (1.24%) and *Pinus* sp. (1.23%) are encountered in low value.

Patharkhola area—In this reserve out of two samples one is productive and proved to be unifloral as evidenced by the dominating taxa namely *Syzygium cumini* (60.45%), followed by other taxa rankwise are *Brassica campestris* (14.87%), *Coriandrum sativum* (4.56%), *Carissa opaca* (3.25%), *Melia azedarach* (2.43%), *Elaeocarpus rugosus* (2.13%), *Symplocos racemosa* (1.90%), *Ilex excelsa* (1.89%), *Aegle marmelos* (1.54%), Poaceae (1.34%), *Sapindus rarak* (1.32%) and *Salmalia malabaricum* (1.20%). Whereas, *Juglans regia* is found in trace values.

***Bhakura area*—**In this reserve out of two samples one is productive and proved to be unifloral as evidenced by the dominating taxa, *Coriandrum sativum* (30.56%) followed by other prominent taxa like *Brassica campestris* (9.34%), *Caesalpinia pulcherrima* (4.34%), *Melia azedarach* (3.60%), *Aegle marmelos* (3.45%), *Acacia catechu* (2.89%), *Jasminum officinale* (2.87%), *Ricinus communis* (2.75%), *Elaeocarpus rugosus* and *Ligustrum indicum* (2.67% each), *Syzygium cumini* (2.56%), Arecaceae (2.43%) and *Juglans regia* (2.34%). Whereas, taxa like *Caltha palustris* (1.90%), *Solanum erianthum* (1.89%), *Sapindus rarak* (1.87%), *Madhuca longifolia* and *Celtis australis* (1.84% each), Asteraceae (1.67%), *Albizia lebbeck* (1.50%), Poaceae (1.45%) and *Ilex excelsa* (1.34%) are found in lower values.

Mansi area—All the two samples in this reserve are found productive and proved to be unifloral.

Sample no. 1 is enriched with lone dominating taxa, *Brassica campestris* (65.67%) followed by other taxa in moderate values are *Coriandrum sativum* (5.49%), *Acacia catechu* (4.50%), Rubiaceae (4.34%), Malvaceae (4.23%), Asteraceae (3.56%), Cyperaceae (2.90%), Poaceae (2.87%) and Acanthaceae (2.34%). Whereas, other taxa are observed in lower values namely Amaranthaceae (1.65%), *Pinus* sp. (1.45%), *Betula* sp. (1.38%), *Myrica sapida* (1.10%) and *Madhuca longifolia* (1.00%)

Sample no. 2 is enriched with single dominating taxa like *Mimosa pudica* (45.89%) followed by other important taxa like *Syzygium cumini* (10.45%), *Cassia fistula* (7.98%), *Brassica campestris* (8.88%), *Butea monosperma* (6.54%), *Madhuca longifolia* (3.45%), *Acacia catechu* (3.14%), *Ilex excelsa* (2.65%) and *Symplocos racemosa* (2.10%). Whereas, rest of the taxa are encountered in lower values like Poaceae and *Ligustrum indicum* (1.78% each), Asteraceae and Malvaceae (1.67% each), *Elaeocarpus rugosus* (1.34%) and *Morus alba* and *Coriandrum sativum* (1.23% each).

From the above account it is also clear that the honeybee preferred two crop plants namely *Brassica campestris* and *Coriandrum sativum* at the highest value for foraging during winter. The high frequency of *Brassica* and *Coriandrum* pollen are mainly recorded in the samples collected during December and January from Bhakura and Mansi area followed by gradual decrease in *Brassica* and *Coriandrum* pollen and increase in secondary pollen types, viz. *Mimosa, Melia, Jasminum*, Rubiaceae, Malvaceae, Asteraceae, *Ilex*, *Symplocos,* etc. although the flowering of *Brassica* lasts upto mid of February in the field. This sudden change in floral fidelity of bees from one to another is quite interesting and probably the application of insecticides in such crop field during peak foraging time might have interfered floral fidelity of honey bees which can be confirmed from the local farmers and Bee keepers. In addition the flowering time of the melliferous species, climatic conditions and human activity (e.g. farming, reforestation and forest fires) are also may be other factors to be considered in understanding the presence or absence of some taxa in the pollen spectra of honeys. The incorporation of summer blooming *Salmalia malabaricum, Madhuca longifolia* and *Syzygium cumini* pollen with winter blooming crop pollen is quite significant and needs to be explained because of its long span of blooming periods. Predominance of winter blooming taxa like *Brassica* (18.59%) and *Mimosa*

PLATE 1

Palynomorphs recovered from honey samples. →

1. *Melia azedarach*
2. *Salmalia malabaricum*
3. *Cassia fistula*
4. *Symplocos racemosa*
5. Anacardiaceae
6. *Butea monosperma*
7. *Caesalpinia pulcherrima*
8. *Ilex excelsa*
9. *Syzygium cumini*
10. *Albizia lebbeck*
11. *Elaeocarpus rugosus*
12. *Lagerstroemia parviflora*
13. Acanthaceae
14. *Pinus* sp.
15. *Betula* sp.
16. *Myrica sapida*
17. Asteraceae (Tubuliflorae)
18. Amaranthaceae
19. *Brassica campestris*
20. *Mimosa pudica*
21. Malvaceae
22. Cereal pollen (Poaceae)
23. Cyperaceae
24. Cluster of pollen showing *Mimosa pudica* and Tubuliflorae
25. Cluster of pollen showing *Syzygium cumini* and *Elaeocarpus rugosus* pollen.

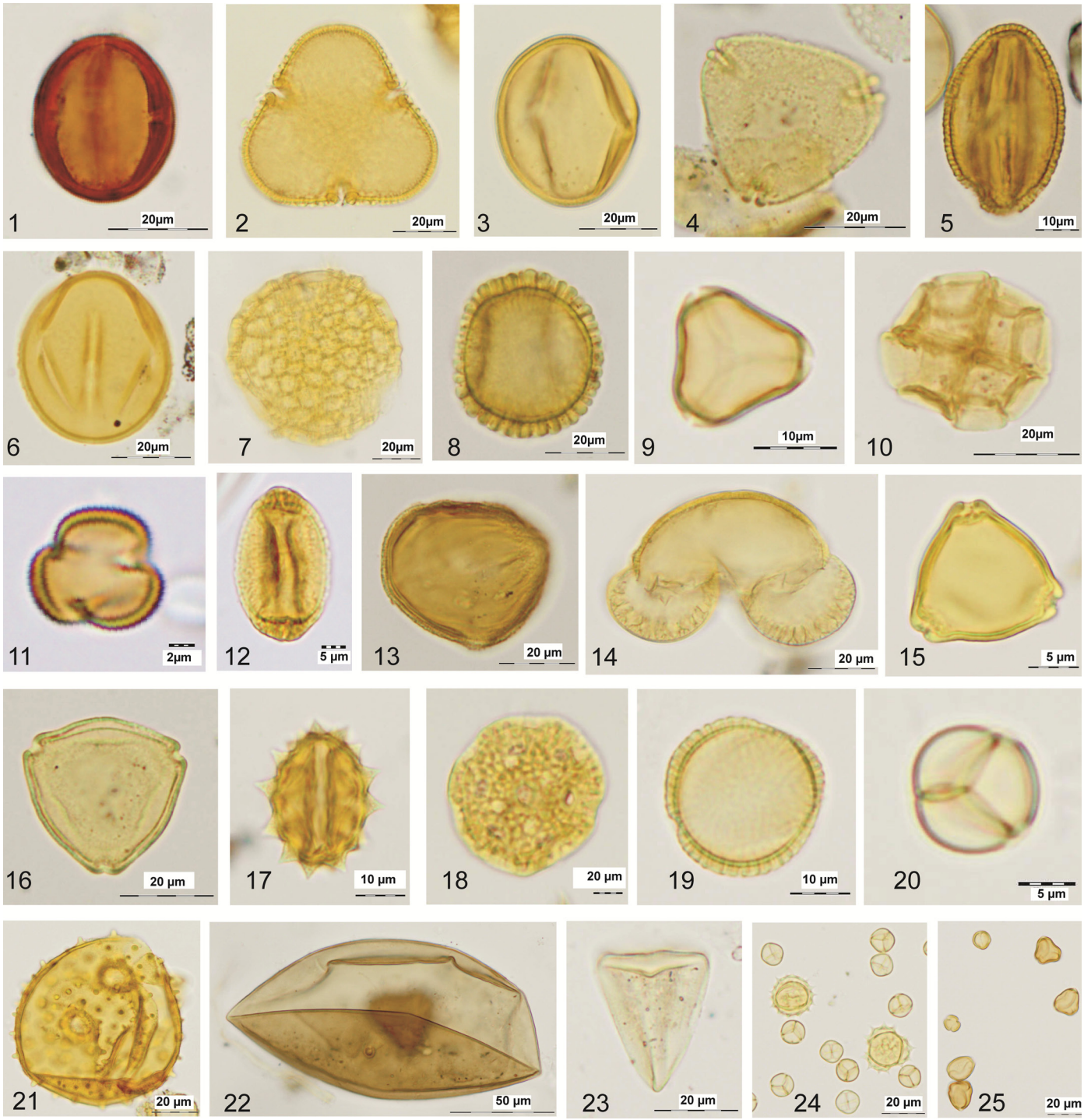
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PLATE 1

(13.44%) over summer taxa in Syalde summer honey sample is also quite interesting and may be due to initiation of honey preparation by bee from winter season. It is striking that the area is familiar for its large number of mango and orange orchards which start blooming from January–February but no pollen are encountered in the honey samples in spite of their regular visit in this period. Thus, melissopalynological investigation may favour the possibilities of using rich flora of certain area in order to develop bee keeping enterprises on commercial basis in which self employment opportunities may be created for many backward communities in the State. It is also suggested that a combined effort of agriculture and apiculture may enhance honey production in floristically rich province like Assam and adjoining areas.

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