

Review

Melissopalynological Studies of Honey from Indo-Gangetic Plain, India

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ABSTRACT

This review attempts to collate the current knowledge on pioneer melissopalynology studies to determine the bee floras of honey collected from Indo-Gangetic Plain region of India. With the help of 127 research papers that are accessible for review, a list of the bee flora of Indo-Gangetic region has been compiled, representing 273 plants serving as the nectar and pollen sources. Knowledge of bee floras of this region will prove to be significant for beekeepers during beekeeping and improving the apiculture industry.

Key words: *Apis*, Bee flora, Honey, Indo-Gangetic Plain, Melissopalynology

INTRODUCTION

Melissopalynology is an applied branch of palynology which deals with the study of both botanical as well as geographical origin of honey through microscopic analysis of pollen grains present in honey (Seethalakshmi 1983, Sivaram 1995, Anklam 1996, Jones and Bryant 2014, Chakraborti and Bhattacharya 2015, Noor et al. 2016). In India, four honeybee species are reported namely *Apis cerena indica*, *A. dorsata*, *A. florea* and *A. mellifera* (Tej et al. 2017). Honeybees depend on floral resources for survival because their main food sources are nectar and pollen (Haydak 1970, Michener 2007, Wright et al. 2018).

Honey is the natural sweet product obtained by honey bees from the nectar of blossoms or sweet deposits from plants, modified and stored in honeycombs. It is highly nutritive with diverse medicinal properties since ancient times. It is also known to have antibiotic and anti-aging properties (Crane 1975, Ramanujam 1994, Mitro 1996, Wahdan 1998). The taste, smell, color and chemical composition of honey depend on its botanical and geographical origin and processing and storage conditions (Dobre et al. 2013). The chemical composition of honey consists of sugars, water, amino acids, proteins, enzymes, flavonoids, phenolic acids, vitamins and minerals.

In the current review, a floral table has been prepared to document the family, genus and

geographical locations around the different seasons of honey on the basis of melissopalynology data recorded by pioneer authors from Indo-Gangetic Plains (Table 1). Summaries of papers presented during scientific conferences were not considered in the present review. In this review, we have seen that some researchers unfortunately reported non-nectariferous (nectar deficient) pollen types along with the nectariferous pollen types from honey samples. The presence of non-nectariferous pollen types may provide an ambiguous result. Honey samples obtained by squeezing the comb may be contaminated with non-nectariferous pollen types. Therefore we also listed non-nectariferous plant data in our review.

HISTORY

In India the melissopalynological studies was started by Deodikar and Thakar (1953) from Maharashtra followed by studies of Nair (1964) in different regions of India. Several significant publications on the pollen analysis of honeys were made by several authors in the different state of India such as Andaman Island (Ganga Kailas et al. 2016, Mudavath et al. 2017), Andhra Pradesh (Ramanujam and Kalpana 1991, 1992, Jhansi and Ramanujam 1990, Jhansi et al. 1991, Lakshmi and Suryanarayan 1997, 2004, Kalpana and Ramanujam 1998, Ramakrishna and Swathi 2013, Mamatha et al. 2018), Assam (Bera et al. 2007, 2009, Dixit et al. 2012,

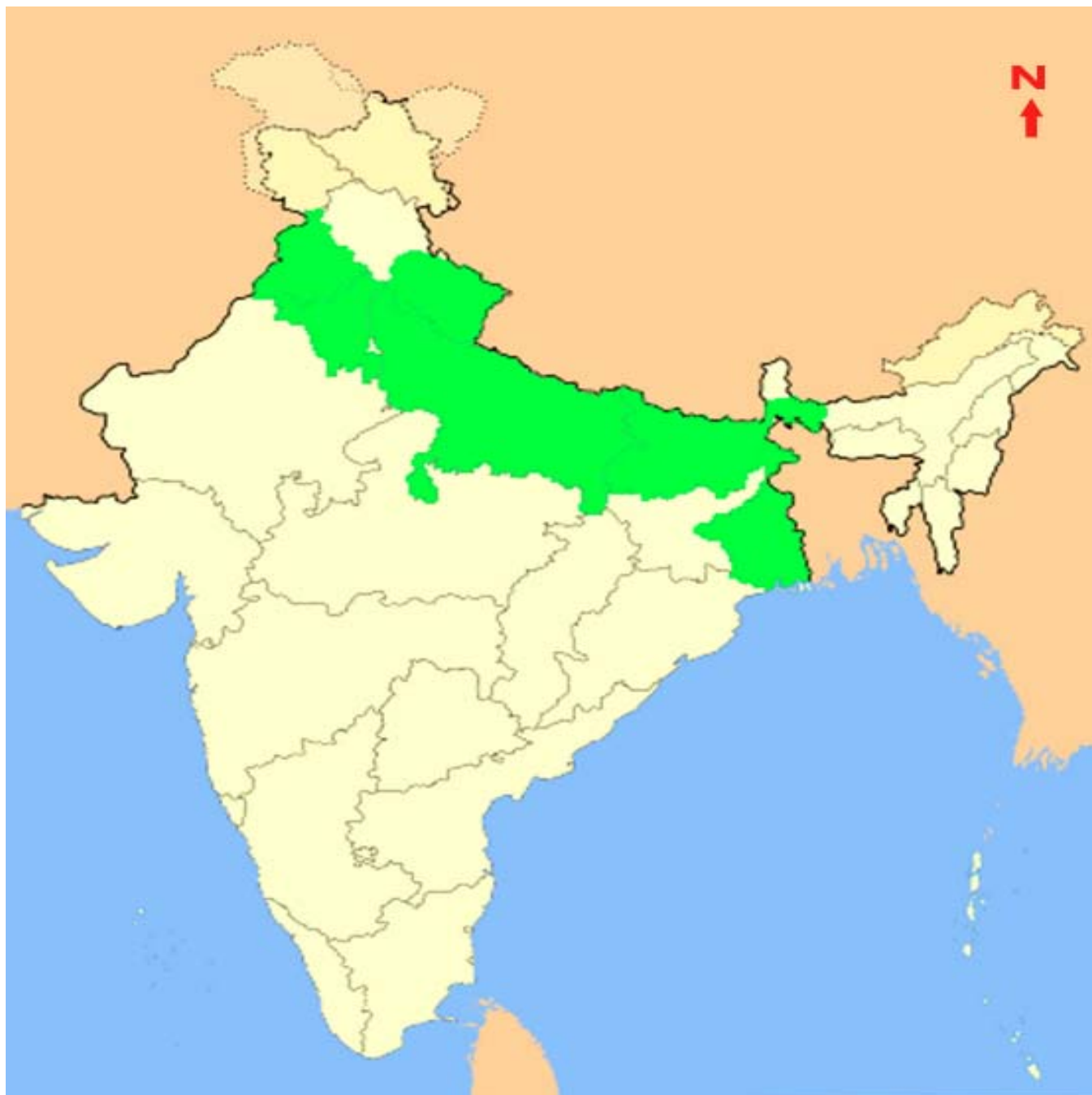


Figure 1. Indo-Gangetic plains region of India

Tripathi et al. 2017), Chhattisgarh (Singh and Dixit 2017), Himachal Pradesh (Attri 2010, Jamwal and Mattu 2019), Karnataka (Bhargava et al. 2009, Chauhan and Murthy 2010, Shubharani et al. 2012, Ponnuchamy et al. 2014), Orissa (Upadhyay and Bera 2012, Upadhyay et al. 2014), Madhya Pradesh (Chauhan and Quamar 2010), Maharashtra (Chaubal 1982, Nayer 1990, Lakshmi and Wakhle 2003, Bhusari et al. 2005, Cherian et al. 2011, Ghugal et

al. 2015, Mate 2015), Sikkim (Bera et al. 1997), Tamil Nadu (Agashe and Mary Scinthia 1995) and Telangana (Devendra et al. 2016).

Indo-Gangetic Plain region, being a vast plain area with diverse vegetation is a resourceful rich area for apicultural industry. Though a number of melissopalynological investigations were done by several workers in this field, the data on potential bee foraging flora in many places of Indo-Gangetic

Table 1. Summary of melissopalynological studies in Indo-Gangetic Plain region, India

S.No.	Plant name	Family	Area	Author Citation
1.	<i>Abelmoschus manihot</i> (L.) Medik	Malvaceae	West Bengal	Sivaram 2001, Mukhopadhyay et al. 2007
2.	<i>Abutilon indicum</i> (L.) Sweet	Malvaceae	Uttarakhand	Tiwari 2012
3.	<i>Abutilon indicum</i> (Link) Sweet	Malvaceae	West Bengal	Dixit et al. 2013
4.	<i>Acacia auriculiformis</i> A. Cunn. Ex Benth.	Fabaceae	West Bengal	Jones and Bryant 1996, Layek and Karmakar 2018
5.	<i>Acacia catechu</i> (L.f.) Willd.	Fabaceae	Uttarakhand	Tiwari 2012; Sahney et al. 2018; Shukla and Kumar, 2020; Shukla and Rao (2022)
6.	<i>Acacia nilotica</i> (Linn.) Willd ex Del	Mimosaceae	Uttar Pradesh, West Bengal	Bera et al., 2007
7.	<i>Acalypha indica</i> L.	Euphorbiaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
8.	<i>Achyranthus aspara</i> L.	Amaranthaceae	Uttar Pradesh	Datta et al. 2008
9.	<i>Acanthus</i> sp.	Acanthaceae	West Bengal	Dixit et al. 2013
10.	<i>Achyranthus aspera</i> L.	Amaranthaceae	Uttar Pradesh	Datta et al. 2008
11.	<i>Aconogonum molle</i> (D. Don) H. Hare	Polygonaceae	West Bengal	Dixit et al. 2013
12.	<i>Adhatoda vasica</i> (L.)	Acanthaceae	West Bengal	Jones and Bryant 1996
13.	<i>Aegle marmelos</i> L.	Rutaceae	Haryana, Uttar Pradesh	Hasansab et al. 2017, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
14.	<i>Ageratum conyzoides</i> L.	Asteraceae	Uttar Pradesh, West Bengal	Dixit et al. 2013, Datta et al. 2008, Noor et al. 2009, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
15.	<i>Ailanthus excelsa</i> Roxb.	Simaroubaceae	Uttar Pradesh, West Bengal	Sahney et al. 2018, Shukla and Rao 2021, Layek and Karmakar 2018
16.	<i>Alangium salviifolium</i> (L.f.) Wangerin	Cornaceae	West Bengal	Jones and Bryant 1996
17.	<i>Albizia lebeck</i> (L.) Benth.	Fabaceae	Uttarakhand, Uttar Pradesh	Datta et al. 2008, Sahney et al. 2018, Shukla and Rao 2021
18.	<i>Allium cepa</i> L.	Liliaceae	West Bengal	Bera et al. 2007
19.	<i>Alnus</i> sp	Betulaceae	Uttarakhand, Uttar Pradesh	Datta et al. 2008
20.	<i>Alternanthera sessilis</i> (L.) DC	Amaranthaceae	Uttar Pradesh	Sahney et al. 2018
21.	<i>Amaranthus</i> sp.	Amaranthaceae	Uttar Pradesh	Sahney et al. 2018
22.	<i>Amomum subulatum</i> Roxb.	Zingiberaceae	West Bengal	Dixit et al. 2013
23.	<i>Anagallis arvensis</i> L.	Primulaceae	Uttar Pradesh	Datta et al. 2008
24.	<i>Anaphalis</i> sp.	Asteraceae	West Bengal	Dixit et al. 2013
25.	<i>Anihocephalus cadamba</i> (Roxb.) Miq.	Rubiaceae	Uttar Pradesh	Sahney et al. 2018
26.	<i>Anigonon leptopus</i> H. & A.	Polygonaceae	Uttar Pradesh, West Bengal	Sahney et al. 2018, Jones and Bryant 1996
27.	<i>Apium</i> sp.	Apiaceae	Uttar Pradesh	Datta et al. 2008
28.	<i>Arachis hypogaea</i> L.	Fabaceae	Uttar Pradesh	Datta et al. 2008
29.	<i>Argemone maxicana</i> L.	Papaveraceae	Uttar Pradesh	Shukla and Rao 2021
30.	<i>Aristolochia</i> sp.	Aristolochiaceae	West Bengal	Dixit et al. 2013
31.	<i>Artemisia vulgaris</i> L.	Asteraceae	West Bengal	Dixit et al. 2013
32.	<i>Aspidopterys nutans</i> (Roxb. ex DC.) Juss.	Malpighiaceae	West Bengal	Dixit et al. 2013
33.	<i>Asystasia</i> sp.	Acanthaceae	West Bengal	Dixit et al. 2013
34.	<i>Azadirachta indica</i> L.	Meliaceae	Haryana, Uttarakhand, Uttar Pradesh	Hasansab et al. 2017, Datta et al. 2008, Shukla and Rao 2020
35.	<i>Bassia butyracea</i> Roxb.	Sapotaceae	West Bengal	Dixit et al. 2013
36.	<i>Bauhinia</i> sp.	Fabaceae	West Bengal, Uttar Pradesh	Dixit et al. 2013
37.	<i>Bellis perennis</i> L.	Asteraceae	West Bengal	Dixit et al. 2013
38.	<i>Berberis insignis</i> Hook.f. & Thomson	Berberidaceae	West Bengal	Dixit et al. 2013
39.	<i>Bergenia</i> sp.	Saxifragaceae	West Bengal	Dixit et al. 2013
40.	<i>Bidens biternata</i> (Lour.) Merr. & Sherff.	Asteraceae	West Bengal	Dixit et al. 2013

S.No.	Plant name	Family	Area	Author Citation
41.	<i>Bidens pilosa</i> L.	Asteraceae	West Bengal	Dixit et al. 2013
42.	<i>Blumea</i> sp. DC	Asteraceae	West Bengal	Ganguly et al. 1984
43.	<i>Boerhavia diffusa</i> L. nom. cons.	Nyctaginaceae	Uttar Pradesh	Sahney et al. 2018
44.	<i>Bombax ceiba</i> L.	Malvaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020
45.	<i>Borassus flabellifer</i> L.	Arecaceae	West Bengal	Jones and Bryant 1996, Dixit et al. 2013, Layek and Karmakar 2018
46.	<i>Bougainvillea</i> sp. Comm.ex Juss.	Nyctaginaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020
47.	<i>Brassica campestris</i> L.	Brassicaceae	Uttar Pradesh, West Bengal	Dixit et al. 2013, Shukla and Rao 2020
48.	<i>Brassica juncea</i> (L.) Czern.	Brassicaceae	Haryana	Hasansab et al. 2017
49.	<i>Brassica nigra</i> L.	Brassicaceae	Uttar Pradesh	Datta et al. 2008
50.	<i>Bridelia retusa</i> (L.) A. Juss.	Phyllanthaceae	West Bengal	Jones and Bryant 1996, Layek and Karmakar 2018
51.	<i>Buddleja asiatica</i> Lour.	Scrophulariaceae	West Bengal	Dixit et al. 2013
52.	<i>Butea monosperma</i> (Lam.)	Fabaceae	Uttar Pradesh	Shukla and Rao 2021
53.	<i>Caesalpinia decapetala</i> (Roth) Alston	Caesalpinaceae	West Bengal	Dixit et al. 2013
54.	<i>Cajanus cajan</i> L.	Fabaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020
55.	<i>Calendula officinalis</i> L.	Asteraceae	West Bengal	Dixit et al. 2013
56.	<i>Calliandra</i> sp.	Fabaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020
57.	<i>Callistemon citrinus</i> (Curtis) Skeels.	Myrtaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020
58.	<i>Camellia</i> sp.	Theaceae	West Bengal	Dixit et al. 2013
59.	<i>Canna indica</i> L.	Cannaceae	West Bengal	Dixit et al. 2013
60.	<i>Cannabis sativa</i> L.	Cannabaceae	Bihar, Uttar Pradesh	Suryanarayana et al. 1992, Sahney et al. 2018, Shukla and Rao 2021
61.	<i>Capparis</i> sp.	Capparidaceae	Uttar Pradesh	Shukla and Rao 2021
62.	<i>Cardamine hirsute</i> L.	Brassicaceae	West Bengal	Dixit et al. 2013
63.	<i>Cardiospermum halicacabum</i> L.	Sapindaceae	West Bengal	Dixit et al. 2013
64.	<i>Carica papaya</i> L.	Cariaceae	West Bengal	Dixit et al. 2013
65.	<i>Cassia fistula</i> L.	Fabaceae	Uttar Pradesh,	Sahney et al. 2018, Shukla and Kumar 2020
66.	<i>Cassia occidentale</i> L.	Fabaceae	Uttar Pradesh, West Bengal	Dixit et al. 2013
67.	<i>Castanopsis</i> sp.	Fagaceae	West Bengal	Dixit et al. 2013
68.	<i>Catharanthus</i> sp.	Apocynaceae	Uttar Pradesh	Datta et al. 2008
69.	<i>Ceiba pentandra</i> (L.) Gaertn.	Malvaceae	West Bengal	Jones and Bryant 1996
70.	<i>Celtis</i> sp.	Celtidaceae	Ultra Khand , Uttar Pradesh	Datta et al. 2008
71.	<i>Chenopodium album</i> L.	Amaranthaceae	Uttar Pradesh	Noor et al. 2009
72.	<i>Chrysanthemum</i> sp.	Asteraceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020
73.	<i>Cicer arietinum</i> L.	Fabaceae	Haryana, Uttar Pradesh	Hasansab et al. 2017, Sahney et al. 2018, Shukla and Kumar 2020
74.	<i>Citrullus lanatus</i> (Thumb.)	Cucurbitaceae	West Bengal	Jones and Bryant 1996
75.	<i>Citrus aurantium</i> L.	Rutaceae	Ultra Khand, Uttar Pradesh	Datta et al. 2008
76.	<i>Citrus sinensis</i> (L.)	Rutaceae	Ultra Khand, Uttar Pradesh, West Bengal	Noor et al. 2009, Datta et al. 2008, Dixit et al. 2013, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
77.	<i>Citrus maxima</i> Merr.	Rutaceae	West Bengal	Jones and Bryant 1996
78.	<i>Coccinea grandis</i> (L.) Voigt	Cucurbitaceae	Uttar Pradesh, West Bengal	Jones and Bryant 1996
79.	<i>Cocos nucifera</i> L.	Arecaceae	Bihar	Suryanarayana et al. 1992
80.	<i>Combretum indicum</i> (L.) De Filippis	Combretaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
81.	<i>Commelina benghalensis</i> L.	Commelinaceae	West Bengal	Layek and Karmakar 2018
82.	<i>Commelina forskalii</i> Vahl.	Commelinaceae	Uttar Pradesh	Datta et al. 2008
83.	<i>Convolvulus microphyllus</i> L.	Convolvulaceae	Uttar Pradesh	Datta et al. 2008

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84.	<i>Coriandrum sativum</i> L.	Apiaceae	Haryana, Uttarakhhand, Uttar Pradesh	Hasansab et al. 2017, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
85.	<i>Crotalaria juncea</i> L.	Fabaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
86.	<i>Croton bonplandianum</i> L.	Euphorbiaceae	Uttar Pradesh	Suryanarayana et al. 1992, Shukla and Rao 2021
87.	<i>Cucumis sativus</i> L.	Cucurbitaceae	Bihar, Uttar Pradesh	Datta et al. 2008
88.	<i>Cucurbita maxima</i> Duchesne	Cucurbitaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
89.	<i>Cyperus</i> sp.	Cyperaceae	Bihar, Uttar Pradesh	Suryanarayana et al. 1992, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
90.	<i>Dahlia variabilis</i> (Willd.)	Asteraceae	Uttar Pradesh	Datta et al. 2008
91.	<i>Dalbergia sissoo</i> Roxb.	Fabaceae	West Bengal; Uttar Pradesh	Dixit et al. 2013, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
92.	<i>Datura stramonium</i> L.	Solanaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
93.	<i>Delonix regia</i> (Boj. ex Hook.) Raf.	Fabaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
94.	<i>Diospyros melanoxylon</i> Roxb.	Ebenaceae	Uttar Pradesh	Datta et al. 2008
95.	<i>Diospyros montana</i> Roxb.	Ebenaceae	Uttar Pradesh	Datta et al. 2008
96.	<i>Duranta erecta</i> L.	Verbenaceae	West Bengal	Jones and Bryant 1996
97.	<i>Erigeron karwinskianus</i> DC.	Asteraceae	UttaraKhand	Datta et al. 2008
98.	<i>Eucalyptus citriodora</i> Hook.	Myrtaceae	Haryana, Uttarakhhand, Uttar Pradesh	Datta et al. 2008, Hasansab et al. 2017, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
99.	<i>Eucalyptus globules</i> Labill.	Myrtaceae	Uttarakhand, Uttar Pradesh	Datta et al. 2008, Sahney et al. 2018
100.	<i>Eupatorium odoratum</i> L.	Asteraceae	West Bengal	Jones and Bryant 1996
101.	<i>Feronia limonia</i> Linn.	Rutaceae	Uttar Pradesh	Shukla and Rao 2021
102.	<i>Flacourtia jangomas</i> (Lour.)	Salicaceae	West Bengal	Jones and Bryant 1996
103.	<i>Foeniculum vulgare</i> Mill.	Apiaceae	West Bengal	Jones and Bryant 1996
104.	<i>Gardenia latifolia</i> Ait.	Rubiaceae	Uttar Pradesh	Datta et al. 2008
105.	<i>Gelonium</i> sp. Roxb. Ex Wild.	Euphorbiaceae	Uttar Pradesh	Datta et al. 2008
106.	<i>Gmelina arborea</i> Roxb.	Lamiaceae	West Bengal	Jones and Bryant 1996
107.	<i>Gossypium hirsutum</i> L.	Malvaceae	Haryana	Hasansab et al. 2017
108.	<i>Grewia hirsute</i> Vahl	Malvaceae	Uttar Pradesh	Sahney et al. 2018
109.	<i>Gymnema sylvestre</i> R. Br.	Apocynaceae	West Bengal	Jones and Bryant 1996
110.	<i>Haldina cordifolia</i> (Roxb.) Ridsdale	Rubiaceae	West Bengal	Jones and Bryant 1996
111.	<i>Helianthus annuus</i> L.	Asteraceae	Haryana, Uttra Khand, Uttar Pradesh	Datta et al. 2008, Hasansab et al. 2017, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
112.	<i>Hibiscus rosa sinensis</i> L.	Malvaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
113.	<i>Holboelia</i> sp.	Lardizabalaceae	UttaraKhand	Datta et al. 2008
114.	<i>Holoptelea integrifolia</i> (Roxb.)	Ulmaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
115.	<i>Hordeum vulgare</i> L.	Poaceae	Bihar	Suryanarayana et al. 1992
116.	<i>Hygrophila auriculata</i> Schumacher	Acanthaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020
117.	<i>Iberis amara</i> L.	Brassicaceae	Uttar Pradesh	Datta et al. 2008
118.	<i>Ipomea alba</i> L.	Convolvulaceae	Uttar Pradesh	Datta et al. 2008
119.	<i>Ipomea batatas</i> (L.) Lam.	Covulvaceae	Uttar Pradesh	Datta et al. 2008
120.	<i>Ipomea purpurea</i>	Convolvulaceae	Uttar Pradesh	Sahney et al. 2018
121.	<i>Ixora</i> sp. L.	Rubiaceae	Uttar Pradesh	Datta et al. 2008
122.	<i>Jatropha gossypifolia</i> L.	Euphorbiaceae	Uttar Pradesh	Datta et al. 2008
123.	<i>Justicia glabra</i> Koen ex Roxb	Acanthaceae	Uttar Pradesh	Datta et al. 2008
124.	<i>Justicia simplex</i> D. Don	Acanthaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021

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125.	<i>Lagerstroemia speciosa</i> L.	Lythraceae	Uttar Pradesh	Shukla et al. (2022)
126.	<i>Lagerstroemia indica</i> L.	Lythraceae	Uttara Khand, Uttar Pradesh	Datta et al. 2008, Noor et al. 2009
127.	<i>Lannea coromandelica</i> (Houtt.) Merr.	Anacardiaceae	West Bengal	Jones and Bryant 1996
128.	<i>Lantana indica</i> Roxb.	Verbenaceae	Uttar Pradesh	Datta et al. 2008
129.	<i>Lathyrus odoratus</i> L.	Fabaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020
130.	<i>Lathyrus sativus</i> L.	Fabaceae	Uttar Pradesh	Shukla and Kumar 2020
131.	<i>Lawsonia inermis</i> L.	Lythraceae	Uttar Pradesh	Chauhan et al. 2017
132.	<i>Lepidium didymum</i> L.	Brassicaceae	Uttar Pradesh	Datta et al. 2008
133.	<i>Leucosceptorum canum</i>	Lamiaceae	West Bengal	Dixit et al. 2013
134.	<i>Leucaena leucocephala</i> (Lam.) de Wit	Fabaceae	West Bengal	Jones and Bryant 1996
135.	<i>Leucus</i> sp.	Lamiaceae	West Bengal	Dixit et al. 2013
136.	<i>Leycesteria</i> sp.	Caprifoliaceae	West Bengal	Dixit et al. 2013
137.	<i>Ligustrum confusum</i> Decne	Oleaceae	West Bengal	Dixit et al. 2013
138.	<i>Linaria</i> sp.	Scrophulariaceae	West Bengal	Dixit et al. 2013
139.	<i>Lippia alba</i> (Mill.)	Verbenaceae	West Bengal	Jones and Bryant 1996
140.	<i>Litchi chinensis</i> Sonn.	Sapindaceae	UttaraKhand, UttarPradesh,	Datta et al. 2008, Noor et al. 2009, Layek and Karmakar 2018, Sahney et al. 2018
141.	<i>Luffa</i> sp.	Cucurbitaceae	West Bengal	Dixit et al. 2013, Datta et al. 2008, Layek and Karmakar 2018
142.	<i>Lycopersicon esculentum</i> Mill.	Solanaceae	UttaraKhand, UttarPradesh,	Dixit et al. 2013, Datta et al. 2008, Layek and Karmakar 2018
143.	<i>Lysimachia japonica</i> Thunb.	Primulaceae	West Bengal	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
144.	<i>Macaranga</i> sp.	Euphorbiaceae	West Bengal	Dixit et al. 2013
145.	<i>Madhuca indica</i> J. F. Gmel.	Sapotaceae	Uttar Pradesh	Dixit et al. 2013
146.	<i>Magnolia</i> sp.	Magnoliaceae	West Bengal	Sahney et al. 2018, Shukla and Rao 2021
147.	<i>Mangifera indica</i> L.	Anacardiaceae	Uttar Pradesh	Dixit et al. 2013
148.	<i>Medicago sativa</i> L.	Fabaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
149.	<i>Melia azedarach</i> L.	Meliaceae	Uttarakhand, Uttar Pradesh	Datta et al. 2008, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
150.	<i>Michelia</i> sp.	Magnoliaceae	West Bengal	Jones and Bryant 1996
151.	<i>Mikania scandens</i> L.	Asteraceae	West Bengal	Dixit et al. 2013
152.	<i>Millettia pimata</i> (L.) Panigrahi	Fabaceae	West Bengal	Jones and Bryant 1996; Dixit et al. 2013; Layek and Karmakar 2018
153.	<i>Mimosa pudica</i> L.	Fabaceae	Uttar Pradesh	Jones and Bryant 1996; Dixit et al. 2013; Layek and Karmakar 2018
154.	<i>Momordica charantia</i> L.	Cucurbitaceae	Uttar Pradesh, West Bengal	Jones and Bryant 1996; Dixit et al. 2013; Sahney et al. 2018; Shukla and Rao 2021
155.	<i>Moringa oleifera</i> Lam.	Moringaceae	Uttar Pradesh, West Bengal	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021, Layek and Karmakar 2018
156.	<i>Morus alba</i> L.	Moraceae	UttaraKhand, Uttar Pradesh	Datta et al. 2008, Shukla and Kumar 2020
157.	<i>Murraya koenigii</i> (L.) Sprengel	Rutaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
158.	<i>Myrica</i> sp.	Myricaceae	UttaraKhand	Datta et al. 2008
159.	<i>Nemophila menziesii</i> H. & A.	Boraginaceae	West Bengal	Dixit et al. 2013
160.	<i>Neolamarckia cadamba</i> (Roxb.) Bosser	Rubiaceae	West Bengal	Layek et al. 2020
161.	<i>Nigella sativa</i> L.	Ranunculaceae	West Bengal	Jones and Bryant 1996
162.	<i>Nyctanthes arbor-tristis</i> L.	Oleaceae	UttarPradesh	Sahney et al. 2018
163.	<i>Ocimum basilicum</i> L.	Lamiaceae	Uttarakhand, UttarPradesh,	Datta et al. 2008; Dixit et al. 2013; Chauhan et al. 2017; Sahney et al. 2018; Shukla and Kumar 2020; Shukla and Rao 2021
164.	<i>Olea glandulifera</i> Wallich ex D. Don	Oleaceae	West Bengal	Bera et al. 2007
165.	<i>Osbeckia</i> sp.	Melastomataceae	West Bengal	Dixit et al. 2013

S.No.	Plant name	Family	Area	Author Citation
166.	<i>Oxalis</i> sp.	Oxalidaceae	Uttar Pradesh, West Bengal	Dixit et al. 2013
167.	<i>Papaver</i> sp.	Papaveraceae	West Bengal	Dixit et al. 2013
168.	<i>Parthenium hysterophorus</i> L.	Asteraceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021, Shukla et al. 2022
169.	<i>Passiflora foetida</i> L.	Passifloraceae	West Bengal	Bera et al. 2007
170.	<i>Pedicularis mollis</i> Wall. ex Benth	Orobanchaceae	West Bengal	Bera et al. 2007
171.	<i>Peltophorum pterocarpum</i> (DC.) K. Heyne	Fabaceae	Uttar Pradesh, West Bengal	Jones and Bryant 1996, Layek and Karmakar 2018, Shukla et al. 2022
172.	<i>Persicaria perfoliata</i> (L.) H. Gross.	Polygonaceae	West Bengal	Bera et al. 2007
173.	<i>Petrea volubilis</i> L.	Verbenaceae	Uttar Pradesh	Sahney et al. 2018
174.	<i>Petunia</i> sp.	Solanaceae	West Bengal	Bera et al. 2007
175.	<i>Phaseolus aureus</i> (Roxb.)	Fabaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
176.	<i>Phaseolus vulgaris</i> L.	Fabaceae	Uttar Pradesh	Shukla and Kumar 2020
177.	<i>Phoenix sylvestris</i> L.	Arecaceae	Bihar, Uttar Pradesh	Suryanarayana et al. 1992, Datta et al. 2008, Chauhan et al. 2017, Sahney et al. 2018
178.	<i>Phyllanthus emblica</i> L.	Phyllanthaceae	Uttar Pradesh, Uttarakhnad	Datta et al. 2008, Shukla et al. 2022
179.	<i>Pimpinella tomentosa</i> Dalzell ex C.B. Clarke	Apiaceae	West Bengal	Dixit et al. 2013
180.	<i>Pisum sativum</i> L.	Fabaceae	Haryana, Uttar Pradesh	Hasansab et al. 2017, Sahney et al. 2018, Shukla and Kumar 2020
181.	<i>Pithecellobium dulce</i> (Roxb.) Benth.	Fabaceae	Uttar Pradesh	Chauhan et al. 2017
182.	<i>Plantago erosa</i> Wall.	Plantaginaceae	West Bengal	Dixit et al. 2013
183.	<i>Plectranthus</i> sp.	Lamiaceae	West Bengal	Dixit et al. 2013
184.	<i>Polygonum aviculare</i> L.	Polygonaceae	Uttar Pradesh	Chauhan et al. 2017
185.	<i>Pongamia pinnata</i> (L.) Pierre	Fabaceae	Haryana	Hasansab et al. 2017
186.	<i>Potentilla reptans</i> L.	Rosaceae	Uttarakhand	Datta et al. 2008
187.	<i>Primula veris</i> L.	Primulaceae	West Bengal	Dixit et al. 2013
188.	<i>Prosopis juliflora</i> (Sw.) DC.	Fabaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
189.	<i>Prosopis spicigera</i> Linn.	Fabaceae	West Bengal	Layek et al. 2020
190.	<i>Prunus</i> sp.	Rosaceae	West Bengal	Dixit et al. 2013
191.	<i>Psidium guajava</i> L.	Myrtaceae	Haryana, Uttar Pradesh	Hasansab et al. 2017, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
192.	<i>Pueraria sikkimensis</i> Prain	Fabaceae	West Bengal	Layek et al. 2015, 2020
193.	<i>Punica granatum</i> L.	Lythraceae	West Bengal	Dixit et al. 2013
194.	<i>Pyrostegia venusta</i> (Ker Gawl.) Miers	Bignoniaceae	Uttar Pradesh	Sahney et al. 2018
195.	<i>Raphanus sativus</i> L.	Brassicaceae	Haryana, Uttar Pradesh	Hasansab et al. 2018, Sahney et al. 2018, Shukla and Kumar 2020
196.	<i>Rhododendron</i> sp.	Ericaceae	Uttarakhand	Datta et al. 2008
197.	<i>Ricinus communis</i> L.	Euphorbiaceae	Uttar Pradesh	Datta et al. 2008, Sahney et al. 2018
198.	<i>Rosa</i> sp.	Rosaceae	Uttar Pradesh, West Bengal	Dixit et al. 2013, Sahney et al. 2018, Layek et al. 2020
199.	<i>Rubia</i> sp.	Rubiaceae	West Bengal	Dixit et al. 2013, Layek et al. 2015
200.	<i>Rubus ellipticus</i> Sm.	Rosaceae	West Bengal	Dixit et al. 2013, Layek et al. 2015
201.	<i>Rumex dentatus</i> L.	Polygonaceae	Uttarakhand, Uttar Pradesh	Datta et al. 2008, Dixit et al. 2013, Sahney et al. 2018
202.	<i>Rumex hastatus</i> D. Don	Polygonaceae	Uttara Khand	Datta et al. 2008
203.	<i>Rungia pectinata</i> (L.) Nees.	Acanthaceae	West Bengal	Dixit et al. 2013
204.	<i>Rungia repens</i> (L.) Nees.	Acanthaceae	Uttar Pradesh	Sahney et al. 2018
205.	<i>Salix</i> sp.	Salixaceae	Uttarakhand	Datta et al. 2008
206.	<i>Salvia</i> sp.	Lamiaceae	Uttara Khand, Uttar Pradesh, West Bengal	Dixit et al. 2013, Datta et al. 2008
207.	<i>Salvia dorii</i> (Kellogg) Abrams	Lamiaceae	Uttar Pradesh	Datta et al. 2008

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208.	<i>Sambucus</i> sp.	Sambucaceae	West Bengal	Dixit et al. 2013
209.	<i>Saxifraga stolonifera</i> Curtis.	Saxifragaceae	West Bengal	Dixit et al. 2013
210.	<i>Schima wallichii</i> (DC.) Korth.	Theaceae	West Bengal	Dixit et al. 2013
211.	<i>Schisandra</i> sp.	Sapotaceae	West Bengal	Dixit et al. 2013
212.	<i>Sechium edule</i> (Jacq.) Sw.	Cucurbitaceae	West Bengal	Dixit et al. 2013
213.	<i>Sedum multicaule</i> Wall.	Crassulaceae	West Bengal	Dixit et al. 2013
214.	<i>Selinum tenuifolium</i> (DC.)	Apiaceae	West Bengal	Dixit et al. 2013
215.	<i>Semecarpus anacardium</i> L.f.	Anacardiaceae	West Bengal	Jones and Bryant 1996
216.	<i>Senna occidentalis</i> (L.) Link	Fabaceae	West Bengal	Jones and Bryant 1996, Layek et al. 2020
217.	<i>Sexamum indicum</i> L.	Pedaliaceae	Haryana, Uttar Pradesh	Hasansab et al. 2017, Shukla et al. 2022
218.	<i>Sida cordifolia</i> L.	Malvaceae	Uttar Pradesh	Sahney et al. 2018
219.	<i>Solanum melongena</i> L.	Solanaceae	Uttar Pradesh	Shukla and Kumar 2020
220.	<i>Solanum nigrum</i> L.	Solanaceae	West Bengal	Dixit et al. 2013
221.	<i>Solanum tuberosum</i> L.	Solanaceae	Uttar Pradesh	Shukla et al. 2022
222.	<i>Solidago virga-aurea</i>	Asteraceae	West Bengal	Dixit et al. 2013
223.	<i>Sonchus arvensis</i> L.	Asteraceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020
224.	<i>Sonchus oleracea</i> L.	Asteraceae	Uttar Pradesh	Chauhan et al. 2017
225.	<i>Sorghum vulgare</i> L.	Poaceae	Bihar	Suryanarayana et al., 1992
226.	<i>Spergula arvensis</i> L.	Caryophyllaceae	West Bengal	Dixit et al. 2013
227.	<i>Spermatocryon suaveolens</i> Roxb.	Rubiaceae	Uttarakhand	Tiwari 2012
228.	<i>Spiraea micrantha</i> Hook.fill.	Rosaceae	West Bengal	Dixit et al. 2013
229.	<i>Sphagneticola trilobata</i> L.	Asteraceae	Uttar Pradesh	Datta et al. 2008
230.	<i>Spondias pinnata</i> (L.f.) Kurz.	Anacardiaceae	West Bengal	Jones and Bryant 1996
231.	<i>Sterculia</i> sp.	Sterculiaceae	West Bengal	Dixit et al. 2013
232.	<i>Sterculia villosa</i> Roxb	Sterculiaceae	Uttarakhand	Tiwari 2012
233.	<i>Streptosolen jamesonii</i> (Benth.) Miers.	Solanaceae	West Bengal	Dixit et al. 2013
234.	<i>Strobilanthes kunthiana</i> (Wall.ex Nees.)	Acanthaceae	West Bengal	Dixit et al. 2013
235.	<i>Symplocos paniculata</i> (Thunb.) Miq	Symplocaceae	West Bengal	Dixit et al. 2013
236.	<i>Syzygium cumini</i> (L.) Skeels.	Myrtaceae	Uttar Pradesh, West Bengal	Dixit et al. 2013, Shukla and Rao 2021
237.	<i>Tagetes erecta</i> L.	Asteraceae	Haryana, Uttar Pradesh	Hasansab et al. 2017, Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
238.	<i>Tamarindus indica</i> L.	Fabaceae	Uttar Pradesh	Shukla and Rao 2021
239.	<i>Taraxacum officinale</i> L.	Asteraceae	West Bengal	Jones and Bryant 1996
240.	<i>Tecoma stans</i> Juss.	Bignoniaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020
241.	<i>Tectona grandis</i> L.f.	Verbenaceae	Uttar Pradesh, West Bengal	Sahney et al. 2018, Jones and Bryant 1996
242.	<i>Tephrosia purpurea</i> (L.) Pers.	Fabaceae	West Bengal	Jones and Bryant 1996
243.	<i>Terminalia arjuna</i> (Roxb. Ex DC)	Combretaceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
244.	<i>Tetragium obtectum</i> (Wall.ex M.A. Lawson)	Vitaceae	West Bengal	Dixit et al. 2013
245.	<i>Thespesia populnea</i> (L.) Sol. Ex. Correa	Malvaceae	Uttar Pradesh	Sahney et al. 2018
246.	<i>Thevetia</i> sp.	Apocyanaceae	West Bengal	Dixit et al. 2013
247.	<i>Thunbergia grandifolia</i> Roxb.	Acanthaceae	Uttar Pradesh	Sahney et al. 2018
248.	<i>Tinospora cordifolia</i> (Thunb.) Miers.	Menispermaceae	Uttar Pradesh	Sahney et al. 2018
249.	<i>Tithonia diversifolia</i> (Hemsl.)A. Gray	Asteraceae	West Bengal	Dixit et al. 2013
250.	<i>Toddalia asiatica</i> (L.) Lam	Rutaceae	West Bengal	Dixit et al. 2013

S.No.	Plant name	Family	Area	Author Citation
251.	<i>Toona ciliata</i> M. Roem.	Meliaceae	Uttar Pradesh	Sahney et al. 2018
252.	<i>Torenia</i> sp.	Scrophulariaceae	West Bengal	Dixit et al. 2013
253.	<i>Trewia nudiflora</i> L.	Euphorbiaceae	Uttar Pradesh	Datta et al. 2008
254.	<i>Trianthema portulacastrum</i> L.	Aizoaceae	Uttar Pradesh	Chauhan et al. 2017
255.	<i>Trichosanthes dioica</i> Roxb.	Cucurbitaceae	West Bengal	Jones and Bryant 1996
256.	<i>Tridax procumbens</i> L.	Asteraceae	Uttar Pradesh	Sahney et al. 2018, Shukla and Kumar 2020, Shukla and Rao 2021
257.	<i>Trifolium alexandrinum</i> L.	Fabaceae	Haryana	Chaudhary 2003, 2004, Jat et al. 2016, Hasansab et al. 2017
258.	<i>Trifolium retense</i> L.	Fabaceae	West Bengal	Dixit et al. 2013
259.	<i>Trigonella</i> sp.	Fabaceae	Haryana	Hasansab et al. 2017
260.	<i>Tropaeolum majus</i> L.	Tropaeolaceae	West Bengal	Dixit et al. 2013
261.	<i>Vernonia cinerea</i> (L.) Less.	Asteraceae	Uttar Pradesh	Chauhan et al. 2017
262.	<i>Veronica persica</i> Poit.	Plantaginaceae	West Bengal	Dixit et al. 2013
263.	<i>Vicia faba</i> L.	Fabaceae	Uttar Pradesh	Sahney et al. 2018
264.	<i>Viola tricolor</i> L.	Violaceae	West Bengal	Dixit et al. 2013
265.	<i>Vitis vinifera</i> L.	Vitaceae	West Bengal	Dixit et al. 2013
266.	<i>Vitex negundo</i> L.	Lamiaceae	West Bengal	Jones and Bryant 1996
267.	<i>Wisteria sinensis</i> (Sims) DC.	Fabaceae	West Bengal	Dixit et al. 2013
268.	<i>Woodfordia fruticosa</i> (L.) Kurz	Lythraceae	West Bengal	Dixit et al. 2013
269.	<i>Xanthium strumarium</i> L.	Asteraceae	Uttar Pradesh	Sahney et al. 2018
270.	<i>Zanthoxylum</i> sp.	Rutaceae	West Bengal	Dixit et al. 2013
271.	<i>Zea mays</i> L.	Poaceae	Bihar, Haryana, Uttarakhand	Suryanarayana et al. 1992, Tiwari 2012, Hasansab et al. 2017
272.	<i>Ziziphus jujuba</i> Mill.	Rhamnaceae	Haryana, West Bengal	Dixit et al. 2013, Hasansab et al. 2017
273.	<i>Ziziphus mauritiana</i> L.	Rhamnaceae	Uttar Pradesh	Shukla and Rao 2021

Plain is sketchy and inadequate. In the current review an attempt was made to sum up the melissopalynological data from various regions of Indo-Gangetic Plains.

AREA DESCRIPTION

The Indo-Gangetic Plain is known for the Indus Valley civilization which was responsible for the birth of ancient culture of the Indian subcontinent. The Indo-Gangetic Plain in India is one of the most water-stressed regions in the world. It is bound by the Himalaya in North of India, which feeds various rivers in the region. The area of the current review work is the Indo-Gangetic plain (Fig. 1) which is chiefly covering the Indian states of Punjab, Haryana, Uttar Pradesh, Uttarakhand, Bihar and West Bengal (Sehgal et al. 2013). The major rivers of this Indo-Gangetic system are the Ganga and the Indus along with their tributaries namely Yamuna, Gomti, Ghaghara, Gandak and Kosi, originates in the Himalayan range. These rivers bring large amount of alluvium from the mountain and deposit it to build the plain. The Indo-Gangetic Plain is located within the subtropical to warm temperate climates characterized by cool and dry winters and warm and wet summers. Agriculture is the primary economic activity in the Indo-Gangetic Plain and depends on rainfall as well as irrigation. The Indo-Gangetic plains, the food bowl of India, are the world's most intensely farmed areas. The main crops grown are rice and wheat. Some other crops like maize, sugarcane and cotton are also grown in this area. The chief nectar and pollen availability periods were found to be January to May and August to December in the Indo-Gangetic Plains of India. The monsoon period is reported to be dearth periods (Suryanarayana et al. 1992).

IDENTIFYING THE POLLEN IN HONEY

Several methods on melissopalynological studies have been proposed. The methods recommended by the International Commission of Bee Botany were followed for pollen grain recovery, analysis and quantification of the pollen contents (Louveaux et al. 1978). Honey was dissolved in

distilled water and centrifuged. The supernatant was discarded. The pollen sediment was then processed for pollen studies using the standard acetolysis method (Erdtman 1960). The identification of the retrieved pollen types of honey was done by using the reference pollen slides and relevant published literature (Nair 1964, Bhattacharya et al. 1983, Pal and Karmakar 2013). The enumeration of identifying pollen types was done by Suryanarayana et al. (1981). Subsequent researchers claimed the other methods of pollen analysis of honey was also taken up and developed in a wider scale (Erdtman 1960, Maurizio 1951, 1975, Vorwohl 1967, Stockmarr 1971, Lieux 1980, Jose et al. 1989, Moar 1985, Feller-Demalsy et al. 1987, Jones and Bryant, 1996, 2001, 2004, Von Der Ohe et al. 2004, Ramirez-Arriaga et al. 2011). The other method developed by Jones and Bryant (2001) is to dilute 10 g of honey in 100 ml of ethyl alcohol (ETOH) instead of water and then centrifuge the dilute solution. In this review, we have found that most researchers have followed Louveaux et al. (1978). Pollen frequency classes and absolute pollen counts were assigned using standard procedures (Louveaux et al. 1978). On the basis of the pollen frequency classes honey can be categorized into three types – unifloral (monofloral) honeys are originated from only one plant species (>45% share of pollen of a single species). Bifloral honeys are originated from two species of plants while multifloral (Polyfloral) honeys from the pollen of several plant species (Von Der Ohe 1994, Barth 2004, Persano and Piro 2004, Ramirez-Arriaga et al. 2011).

Most of the melissopalynological work reported by various workers used light microscope as well as scanning electron microscope to identify and interpret the pollen present in a particular honey. Analyses have been carried out on melissopalynological data in quantitative studies to obtain more robust characterization of honeys in term of their botanical as well as geographical origin (Herrero et al. 2002, Corbella et al. 2008, Aronne and De micco 2010).

MELISSOPALYNOLOGICAL STUDIES IN INDO-GANGETIC PLAINS

Melissopalynology has a rich history in Indo-Gangetic Plain India with a number of studies done

on honey. The Indo-Gangetic Plains may be divided into two regions: Western-north region (The Punjab-Haryana Plains) and Northeastern region (The Ganga Plain) (Sehgal et al. 2013).

Western-north region (Punjab-Haryana Plains)

References about pollen analysis of honey and pollen loads from western-north region (the Punjab-Haryana Plains) are not frequent. The knowledge of nectar and pollen found in honey was initiated by Rahman and Singh (1941). Based on the current knowledge, Lakshmi and Wakhle (2003) examined honey sample collected from various phytogeographical region from Kashmir to Kanyakumari including Punjab (5 honey samples from Pathankot) and Haryana (12 samples from Kurukshetra, Karnal, Yamuna nagar and Ambala) region. They reported *Brassica* sp., and *Trifolium* sp., as unifloral honey. The other frequent bee flora in pollen spectrum of honeys from Punjab and Haryana region was *Coriandrum sativum*, *Citrus* sp., *Dalbergia sissoo*, *Eucalyptus* sp., *Helianthus annuus*, *Luffa* sp., and *Zea mays*.

Like Punjab not much work was reported from Haryana. The bee flora of honey collected from Haryana has been studied by pioneer authors (Sihag 1983, 1990). *Trifolium alexandrinum* as a highly valuable crop for both nectar and pollen is reported from Haryana for honey production (Chaudhary 2003a, b, c, 2004). Jat et al. (2016) also reported *T. alexandrinum* as a source of honey and pollen from Haryana. Recently a detailed melissopalynological study of *Apis mellifera* L. honeys and corbicular pollen (pollen baskets) collected from Hisar during different season was done by Hasansab et al. (2017). They reported 26 pollen types representing 23 genera and 18 plant families. The reported pollen types were *Acacia catechu*, *Aegle marmelos*, *Azadirachta indica*, *Brassica juncea*, *Callistemon lanceolatus*, *Cicer arietinum*, *Citrus sinensis*, *Coriandrum sativum*, *Gossypium hirsutum*, *Helianthus annuus*, *Sesamum indicum*, *Tamarindus indica*, *Pongamia glabra*, *Phoenix dactylifera*, *Raphanus sativus*, *Trianthema portulacastrum*, *Trifolium alexandrinum*, *Trigonella* sp., and *Ziziphus jujube*.

North-eastern region (The Ganga plains)

The north-eastern region includes upper Ganga plain (Uttar Pradesh and Uttarakhand), Middle Ganga

Plain (Bihar) and lower Ganga Plain (West Bengal). Extensive pollen studies of honey and pollen from inside hives of pollen loads were carried out in the Upper Ganga region (Sharma and Nair 1965, Chaturvedi 1977, 1989, Chaturvedi and Sharma 1973, Garg and Nair 1993, 1994, Garg 1996, 2006, Tiwari and Tiwari 2009, Tiwari et al. 2010, 2012). A large variety of pollen types were retrieved and identified from honey samples collected from different regions of upper Ganga Plain depending upon blooming period. A total of 98 bee forage plant taxa have been documented as bee forage plants from Uttarakhand state (Datta et al. 2008). The pollen spectrum of honey of the Uttarakhand as an association of *Brassica*, *Erigeron*, *Eucalyptus*, *Helianthus*, *Litchi*, *Prunus*, *Rumex* and *Myrica* recorded as dominant pollen type. The other pollen types were documented as secondary pollen types in polyfloral honey such as *Rhus parviflora*, *Sesamum indicum*, *Amaranthus* sp., *Impatiens* sp., *Lamiaceae*, *Myrtaceae* and *Prunus* species (Datta et al. 2008). Dixit et al. (2013) examined honey samples produced from the western zone of Almora district of Uttarakhand. The pollen types *Alnus nepalensis*, *Anemone obtusiloba*, *Betula utilis*, *Brassica campestris*, *Caesalpinia pulcherrima*, *Coriandrum sativum*, *Fragaria nubicola*, *Impatiens sulcata*, *Mimosa pudica*, *Quercus semecarpifolia*, *Rhododendron campanulatum*, *Rubus ellipticus*, *Schima wallichii*, *Salmalia malabaricum*, *Sapindus rarak* and *Syzygium cumini* were the dominant pollen types in the unifloral honey.

Botanical investigation in melissopalynology by Chauhan and Trivedi (2011) and Chauhan et al. (1990, 2010, 2013, 2015, 2017) were carried out at the Birbal Sahni Institute of Palaeoscience (BSIP) Lucknow with the aim of analyzing the honey samples and pollen load collected from Lucknow and Unnao districts Uttar Pradesh. *Ageratum conyzoides*, *Amaranthus* sp., *Azadirachta indica*, *Brassica campestris*, *Coriandrum sativum*, *Eucalyptus globulus*, *Feronia limonia*, *Grewia* sp., *Litchi chinensis*, *Madhuca indica*, *Prosopis spicigera*, *Prosopis juliflora*, *Pimpinella tomentosa*, *Syzygium cumini*, *Tamarindus indica* and *Ziziphus* sp., were recorded as dominated frequent pollen types. The other pollen types were *Aegle marmelos*, *Capparis* sp., *Cassia fistula*, *Ficus* sp., *Lagerstroemia parviflora*, *Murraya koenigii*, *Phoenix sylvestris*,

Pimpinella tomentosa, *Prosopis spicigera*, *Ricinus communis*, *Tinospora cordifolia*, *Xanthium strumarium* and *Zea mays*. Datta et al. (2008) documented 83 pollen taxa from Uttar Pradesh while working on mapping of key bee flora of upper Gangetic Plain. Sahney et al. (2018) and Shukla and Rao (2021) also studied twenty and eighteen honey samples of Uttar Pradesh, respectively, and presented similar data on plant taxa studies during winter and summer season respectively done in Uttar Pradesh. Recently Shukla et al. (2022) worked on pollen diversity data of Prayagraj district Uttar Pradesh to determine floral bee foraging preferences by comparing the pollen spectra of the honey samples collected from different localities of northern and southern region during different honey flow periods. They recorded *Brassica campestris*, *Coriandrum sativum* and *Peltophorum pterocarpum* was predominant pollen type. The other most frequent pollen taxa identified in polyfloral honey were *Aegle marmelos*, *Albizia lebbbeck*, *Bauhinia* sp., *Bombax ceiba*, *Butea monosperma*, *Cajanus cajan*, *Capparis* sp., *Cicer arietinum*, *Citrus* sp., *Clitoria ternatea*, *Crotolaria juncea*, *Dalbergia sissoo*, *Datura stramonium*, *Delnox regia*, *Eucalyptus globulus*, *Feronia limonia*, *Ficus* sp., *Hibiscus rosa-sinensis*, *Holoptelea integrifolia*, *Lagerstroemia* sp., *Mangifera indica*, *Medicago sativa*, *Moringa oleifera*, *Morus alba*, *Murraya koenigii*, *Ocimum sanctum*, *Prosopis juliflora*, *Parthenium hysterophorus*, *Pisum sativum*, *Psidium guajava*, *Phyllanthus emblica*, *Sesamum indicum*, *Solanum* sp., *Tagetes erecta*, *Tridax procumbens*, *Tinospora cordifolia* and *Ziziphus* sp.

In Bihar, The Middle Ganga Plain region, Suryanarayana et al. (1992) documented significant foraging behavior differences found in the pollen sources of *Apis cerana* Fabr and *A. mellifera* L. They reported 40 and 48 species served as pollen sources to *A. cerana* and *A. mellifera*, respectively. They reported *Parthenium hysterophorus* was not foraged by *A. cerana* while it was recorded as the chief pollen source for *A. mellifera* which was also reported by Suryanarayana and Singh (1989) and Rakesh and Chaudhary (1994). The dominant pollen sources were *Brassica* sp., *Cajanus cajan*, *Cannabis sativa*, *Cleome* sp., *Citrus* sp., *Cosmos bipinnatus*, *Cocos nucifera*, *Cucurbita* sp., *Cyanotis* sp., *Cyperus* sp., *Helianthus annuus*, *Hordeum vulgare*, *Pisum*

sativum, *Phoenix sylvestris*, *Phyllanthus emblica*, *Sesamum indicum*, *Spondias pinnata*, *Trigonella corniculata*, *Vigna sp.*, and *Zea mays*.

The lower Ganga Plain includes the whole of West Bengal. West Bengal is a state in eastern India situated between the Himalayas and the Bay of Bengal. In West Bengal, some melissopalynological research has been published on honey collected by different honey bees, namely *Apis mellifera*, *A. cerana*, *A. dorsata* as well as *A. florea* (Ganguly and Chandra 1980, Mondal 1980, Chandra and Ganguly 1981, Kumar 2000, Bandopadhyay and Bera 2005, Bandopadhyay et al. 2005, Mukhopadhyay et al. 2007, Chandra and Sharma 2011, Pal and Karmakar 2013, Kamble and Pandit 2015, Layek et al. 2015, Layek and Karmakar 2018, Chakraborty and Saha 2019, Layek et al. 2020). Ganguly et al. (1984) analyzed honey samples from Balurghat and Jalpaiguri, West Bengal. They made a comparative study of pollen types of these two localities. They reported *Ageratum conyzoides*, *Azadirachta indica*, *Blumea lacera*, *Bombax ceiba*, *Brassica nigra* and *Coriandrum sativum*. Jana et al. (2002) palynologically analyzed honeys including both apiaries as well as squeezed honeys from Murshidabad district West Bengal. Majority of honey samples were unifloral types with *Brassica sp.*, *Coriandrum sp.*, and *Zizyphus sp.*, etc. indicating the bee foraging source during winter. Mukhopadhyay et al. (2003) examined honeys from the Sub Himalayan region of Bengal. They reported *Aristolochia sp.*, *Rosa sp.*, *Brassica sp.*, *Bidens pilosa* and *Camellia sp.*, from unifloral as well as multifloral honey. Other pollen grains *Phoenix paludosa*, *Sonneratia apetala*, *Ceriops sp.*, *Bruguiera sp.*, etc. were reported during mid-summer season from Sundarbans, West Bengal (Jana and Bera, 2004; Chakraborti and Bhattacharya, 2011a). *Borassus*, *Sesamum*, *Coriandrum*, *Brassica* and *Peltophorum* were also documented by Chakraborti and Bhattacharya (2011b) while they evaluated floristic composition and vegetation impact over the bee forage.

More recently, in the different districts such as Bankura, Birbhum, Hooghly, Paschim Burdwan, Paschim Medinipur, Purba Burdwan and Purba Medinipur of West Bengal, Layek et al. (2015, 2016, 2020a, b) and Layek and Karmakar (2016, 2018) studied honey samples *Apis florea* F., *A. dorsata* F.

and *A. mellifera* L. during winter, spring and summer season. One hundred five species belong to 38 plant families were recorded as bee flora from West Bengal (Layek et al. 2020a). The most frequently encountered plant families were Arecaeaceae, Asteraceae, Cucurbitaceae, Fabaceae, Lamiaceae, Malvaceae, Myrtaceae and Rutaceae. The most dominated pollen types were *Alangium salviifolium*, *Azadirachta indica*, *Borassus flabeilifer*, *Cocos nucifera*, *Croton bonplandianum*, *Milletia pinnata*, *Peltophorum pterocarpum*, *Phyla nodiflora*, *Sesamum indicum*, *Syzygium reticulatum*, *Tamarindus indica*, *Terminalia arjuna*, *Trema orientalis*, *Zizyphus mauritiana* (during summer), *Bridelia retusa*, *Citrus sp.*, *Lippia alba*, *Neolamarckia cadamba*, *Semecarpus anacardium*, *Tridax procumbens* (monsoon), *Acacia auriculiformis*, *Eucalyptus globulus*, *Haldinia cordifolia*, *Mimosa pudica*, *Zizyphus mauritiana* (autumn), *Brassica nigra*, *Butea monosperma*, *Coriandrum sativum*, *Holoptelea integrifolia*, *Lannea coromandelica*, *Phoenix sylvestris*, *Shorea robusta* (winter), *Ailanthus excelsa*, *Alangium salviifolium*, *Dalbergia sissoo*, *Lannea coromandelica* (during spring). The non-nectariferous pollen types were *Capparis zeylanica*, *Echinochloa frumentacea*, *Nelumbo nucifera*, *Papaver somniferum*, Poaceae type and *Solanum melongena*.

Hazra et al. (2021) investigated honeys of *Apis florea* from Purulia district West Bengal during spring season. They found *Terminalia arjuna* an important subsistence pollen source for honeybees. *Apis florea* also foraged other plant types were *Pedilanthus tithymaloides*, *Borassus flabellifer*, *Croton bonplandianum*, *Citrus sp.*, *Flacourtia jamgomias*, *Lannea coromandelica*, *Semecarpus anacardium*, *Tamarindus indica* and members of family Asteraceae.

CONCLUSIONS

This review shows sufficient melissopalynological studies are available from Indo-Gangetic Plains, India which demonstrate the richness of the floral diversity and its utilization in honey production. Around 273 plants are documented as bee forage plants for honey production in Indo-Gangetic Plain region of India. Asteraceae, Cruciferae, Fabaceae and

Myrtaceae proved to be chief contributors of nectar as well as pollen in honey production. This review throws light on the role of the beekeeping activities not only improve the economy of the local inhabitants but also beneficial in ecological conservation. Although bee-keeping is being done throughout the Indo-Gangetic Plain region, Ganga Plains such as Uttarakhand, Uttar Pradesh, Bihar and West Bengal are the most rich in floral wealth for beekeeping than the Punjab and Haryana Plains.

In terms of the knowledge of bee flora and distribution of apiarie boxes in a particular area by avoiding saturated place, beekeepers can achieve the true potential of the industry (Silva et al. 2013). The increasing apiary industrial activities not only improve the economy of the local inhabitant but also beneficial in the conservation of biodiversity aspects. It will also boost socioeconomic condition by enhancing the monetary and self-employment opportunities. The vast and rich vegetation of Indo-Gangetic Plain stipulates the need for complete and comprehensive melissopalynological investigation on the regional basis to characterize and formalize the relationship between plants and honeybees. Most of the bee flora from Indo-Gangetic Plain was documented under wild as well as cultivated plants. The reason behind it may be the fact that this vast plain is characterized by extensive agriculture and urbanization with sparse deciduous forest. Many of the identified honey plants are also economically important such as cereals, ornamental plants, fibres, weeds, fruits, timbers, spices, vegetables, nuts and medicinal plants. It is advised to promote the populations of *Brassica* sp., *Borassus flabellifer*, *Cocos nucifera*, *Coriandrum sativum*, *Dalbergia sissoo*, *Eucalyptus* sp., *Helianthus annuus*, *Holoptelea integrifolia*, *Milletia pinnata*, *Psidium guajava*, *Syzygium cumini*, *S. reticulatum*, *Sesamum indicum*, *Tamarindus indica*, *Trifolium repens*, *Zea mays* and *Ziziphus mauritiana* in Indo-Gangetic Plain.

ACKNOWLEDGEMENTS

Vibhasa Shukla is grateful to the University Grant Commission, New Delhi, India, for financial support under a female-candidate postdoctoral fellowship, and to the Head of the Botany Department, University of Delhi, for providing the necessary

facilities for this work.

Conflict of interest: The authors declare no conflict of interest.

Authors' contribution: VS collated the literature, prepared the draft and finalised the manuscript. KSR supervised and participated in finalization of the manuscript.

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Received: 20th December 2021

Accepted: 18th February 2022