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POLLEN STUDY IN RELATION TO BEE PASTURAGE

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Introduction. The importance of a full knowledge of bee pasturage is well known to the practical bee-keeper. Almost complete treatises about bee flora exist in all the chief honey producing countries. So far as South India is concerned, the industry is still in its infancy. Except for the records of Ramachandran (1937) and Venkatasubbayya (1938), no detailed information appears to be available and the present study was undertaken to supplement the information provided by them.

But the attempt to ascertain plant sources for honey and pollen has in almost all studies reported in India, mainly been confined to the location of flowers actually visited by bees. This method cannot be deemed satisfactory, for it may be that plant sources growing at a long distance away from the apiary are missed. Also the worker's personal prejudices as to the usefulness or otherwise of a particular source may sometimes vitiate the reliability or completeness of the list of plants arrived at.

The study of the external morphology of pollen grains has always formed a subject of absorbing interest to botanists. Pope (1925) and Wodehouse (1928 and 1935) have studied the morphological features of pollen grains which are characteristic of the several families, the genera and the species of plants. From their observations, it seems possible that such characters as the size and shape of the pollen grains, the number and arrangement of germ pores and furrows, the character of reticulations and of spines, and the texture of the surface can be utilized in ascertaining bee pasturage. The present author is not aware of any work in which the pollen characters have been utilized for ascertaining bee pasturage in India. From the observations made on the pollen carried by the bees, the plants that are visited by them have been located and the seasons and the hours during which such visits are made have also been determined.

Material and Methods. Wodehouse (1935) has extensively used the methyl green glycerine jelly method for classifying pollen. His method has been used in the present study. The method, briefly stated, consists of the following processes. A small amount of pollen is placed on a micro slide and a drop or more of 95 per cent. alcohol is added, and the pollen stirred with a needle. The alcohol removes the oily matter found on the surface of the pollen grains, and also the fluid used by bees for moistening the pollen. The surplus alcohol is drained off by means of a bit of cotton wool and before the slide is completely dry, the required amount of warm methyl green glycerine jelly (previously kept ready) is added. The slide is warmed and covered over with a warm cover slip and examined after two or three days which period is necessary for the pollen grains to be properly stained.

Where absolute shape of the pollen grain is to be determined, the methyl green glycerine jelly method wherein the pollen grain is moistened, is unsatisfactory according to Ferguson and Coolidge (1932). Since it is not the aim of the present investigation to determine the absolute shape and size of the pollen as may be necessary in botanical investigations, and since the pollen from both the sources, viz., directly from the plant and that obtained through the bees, was moistened, the objections held by Ferguson and Coolidge (1932) do not apply to the present study. According to Casteel (1912), Phillips (1926) and Parker (1926) the bee moistens the pollen before transferring its load into the pollen baskets. Since it is practically impossible to obtain dry pollen from the bees, the examination of dry pollen as recommended by Ferguson and Coolidge (1932) is out of question.

The findings which were arrived at through the study of pollen borne by the bees were checked by visiting the plants and observing the bees at work on such plants.

Almost all flowers available in the locality were collected and their pollen grains were mounted as above. Such slides from 64 species formed the keys for identifying the pollen brought by bees.

Species visited by bees. (a) *Pollen species.* Pollen loads brought by bees were collected almost at weekly intervals. To enable the accurate determination of the hour during which each species is visited by bees, pollen was collected from the incoming bees every hour taking at the rate of about four bees per hour picked up at random. The pollen grains were separately packed in paper and taken to the laboratory, and kept mounted for identification noting on the slide the date and hour at which the pollen was collected. These were identified with the help of the key slides and full information as to the hours during which each pollen species was useful to bees has been obtained. Plants like *Tribulus terrestris, Leucaena glauca* and *Psidium guajava* are useful exclusively for pollen. A list of 17 such species has been obtained.

(b) *Nectar species.* The general method of picking bees at random at hourly intervals on particular days not more than a fortnight apart was continued in this case also. Parker (1926) states that pollen grains always adhere to one part or the other of the body of the bees while they gather nectar from flowers. In the case of the bee returning to the hive with nectar, no pollen load is found in the pollen baskets, but some quantity of pollen adheres to some part of the body of the bee. This pollen was removed by placing a bee on a slide and moistening it thoroughly with a few drops of 95 per cent. alcohol. The alcohol washes down the pollen which is left on the slide after the evaporation of alcohol. The slide is then stained with methyl green glycerine jelly as above and examined for the pollen. Only those species which have not been identified as pollen species as per test (a) above are considered as useful exclusively for nectar. Plants like cotton, and *Tamarindus indica* belong to this category and 15 such species have been identified as a result of the present study.

There is, however, difficulty in exactly demarcating the hourly periods during which particular species are useful for nectar. The position may be more clearly illustrated with an example. During the months of December and January, both pumpkin *(Cucurbita maxima)* and cotton were found useful for nectar. While pumpkin is frequented by bees from early morning up to about 10 a. m., cotton flowers are visitied only after 9 a. m. Pollen grains adhering to the body of incoming bees may indicate that pumpkin is visited only till 9 a. m., as the bee which was working till then on this source, may afterwards turn its attention to cotton. Tests carried out after 9 a. m. will reveal the presence of pollen grains from both sources. Hence it is difficult to state at what hour a particular species has ceased to be useful. Conclusions in this regard were, however, arrived at only after actually visiting the species in the field. In the above case, for example, very few bees were seen inside the pumpkin flowers after 10 a. m., and absolutely none at all after 11 a. m. It was concluded, therefore, that pumpkin flowers served as a nectar source for bees, only till about 10 a. m.

(c) *Species useful for both pollen and nectar.* Dual purpose species like *agathi (Sesbania grandiflora)* were identified in the following manner. Using the method (a), the pollen loads brought by bees are identified as those from *Sesbania grandiflora.* A test for the nectar gatherers as per method (b) also shows that *agathi* is the source of the nectar. The point that has now to be considered is whether this test (b) is successful simply because the bee has in a previous trip visited *Sesbania grandiflora.* If the bees had visited another species for nectar, then there would be pollen of that species adhering to its body. The absence of such foreign pollen on a number of bees would prove that *agathi (Sesbania grandiflora)* is both a nectar and pollen source. And this point is further confirmed by field observations.

Only six species were found to serve a dual purpose of furnishing nectar and pollen. If a pollen gatherer collects both nectar and pollen from one and the same species in the same trip, it is likely that the fact regarding nectar utilization would be missed. Since all the species the pollen of which was gathered from the bees were visited by the author in the field, and since every care was taken to observe whether pollen-collecting bees also gather nectar from the flowers of the same species, it is likely that no dual purpose species has been missed. Pollen collectors were not noticed to gather nectar in the same trip. A bee engaged in pollen collecting continued to do that work only. Phillips (1926) cites the work of Bonnier* and states that there are separate pollen carriers and nectar gatherers in the hive.

Out of 64 species collected to serve as a key for the identification of pollen, only 38 have been found to be utilised by bees. The others are not at all visited by them.

Attraction of bees to floral colours. Von Frisch (1937) states that bees do not distinguish fine shades of colour and are in a sense colour-blind

* Bonnier, Gaston. 1906. *Sur la division du travail chez les abeilles. Comptes rendus hebdomadaires des seances de l' academie des sciences*, CXLIII, pp. 941–946.

particularly to red blossoms to which bees are, however, attracted on accoun of the reflection of ultra-violet rays. In Table I the colours of the various flowers are grouped :—

TABLE I

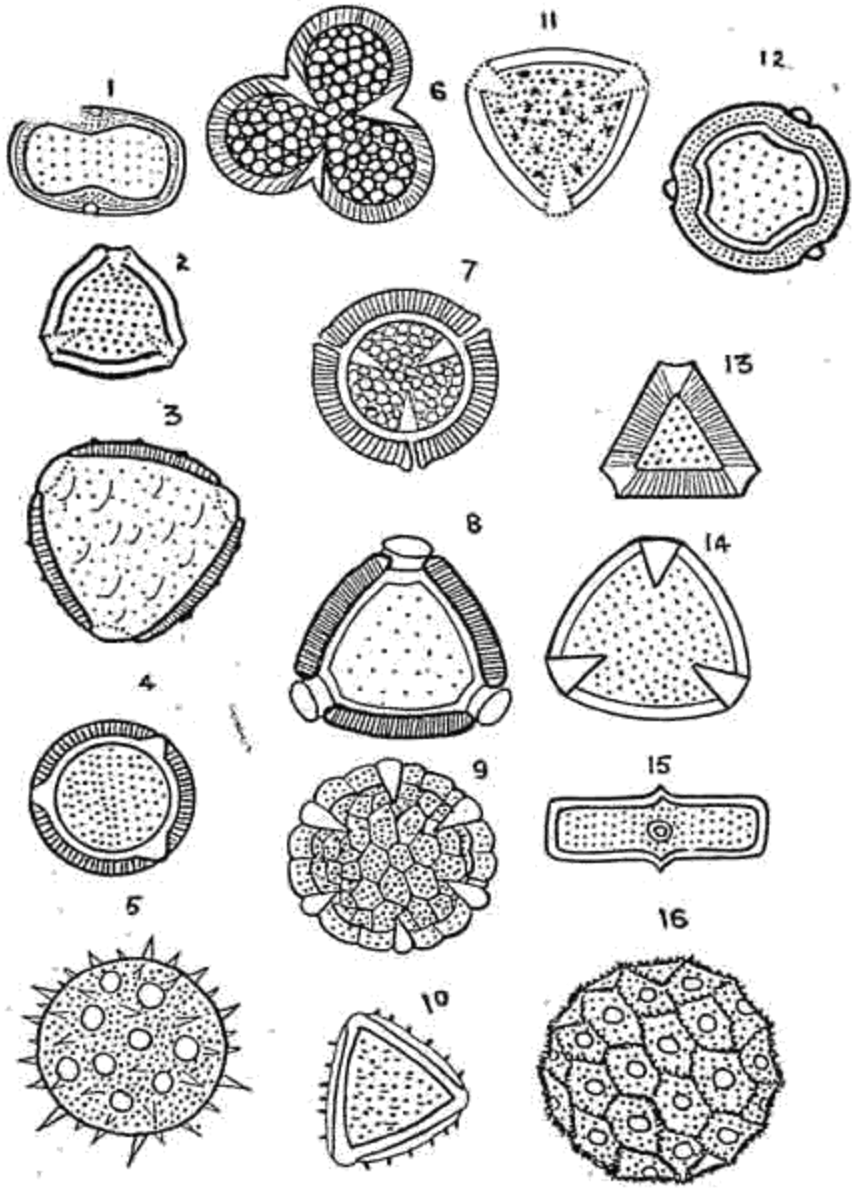
Number of species grouped as per floral colours.

Flower colour.	Key slides		Bee flora	
	Number	Percentage of total	Number	Percentage of total
White	27	42	17	44
Yellow	21	32	15	39
Total	48	74	32	83
Red	3	5	2	5
Blue	3	5	1	3
Pink	3	5	1	3
Rose	2	3	1	3
Green	2	3	...	...
Orange	2	3	...	...
Grey	1	2	1	3
Grand Total	64	100	38	100

In assessing the colours of such flowers as *Tamarindus indica* which have two or more colours on their calyx and corolla, the predominant colour, viz., yellow, has only been taken into consideration.

From Table I it will be seen that out of 64 species which formed the keys, 74 per cent. have white and yellow flowers. Out of the 38 species utilised by bees, 83 per cent. possess yellow and white flowers. In the locality under study, therefore, the flora appears to consist of a large population of white and yellow flowered species and it is seen that out of 48 such species, as many as 32, or 67 per cent. are utilized by bees. But of the remaining 16 species having colours other than yellow and white, only 38 per cent. (6 species) are made use of by the bees. It looks as though bees show a particular preference to yellow and white colours. This point, however, requires further study.

It is relevant at this stage to mention a few observations made in regard to the colour sense in bees. Many bees working on the yellow flowers of *Tribulus terrestris* were seen to alight on similar coloured (though of a different shade) flowers of *Cleome viscosa* apparently by mistake, and then perhaps after detecting the scent, immediately leave the latter without collecting any pollen. Similar observations were made on bees visiting the white and two-lipped flowers of *Justicia tranquebariensis* and the flowers in heads of *Lagasca mollis*. These observations go to show that bees do not recognise shades of colours. They also suggest that even shapes of flowers are missed.



Explanation of Figures.

The diagrams are freehand drawings of pollen grains mounted in methyl green glycerine jelly. They are not drawn to scale and in some cases are slightly diagrammatic for purposes of clarity in print.

1. *Justicia tranquebariensis.*
2. *Trichodesma indicum.*
3. *Cereus peruvianus* (?).
4. *Cleome viscosa.*
5. *Ipomoea carnea.*
6. *Euphorbia heterophylla.*
7. *Ricinus communis.*
8. *Calophyllum inophyllum.*
9. *Ocimum canum.*
10. *Dolichos biflorus.*
11. *Sesbania grandiflora.*
12. *Moringa olifera.*
13. *Psidium guajava.*
14. *Argemone mexicana.*
15. *Coriandrum sativum.*
16. *Tribulus terrestris.*

Shape of the flower in relation to the method of pollen collection. Iow considering the shape of the flower, Parker (1926) classifies flowers which are useful to bees into four groups, viz., open type, tubular type, closed type, and spike type. This classification, of course, does not strictly conform to the method generally followed by botanists in describing the shape of flowers. For example, the flowers which are said to be tubular and funnel shaped by botanists have all been classed under the tubular type by Parker (1926). In discussing the utility of flowers for nectar and pollen, it is convenient to group them under various types, and it seems feasible to adopt Parker's method of classification.

In the present study, the Ipomoeas and some of the cucurbitaceous plants can be classed under the tubular type, and they are useful chiefly as nectar sources. The papilionaceous and the labiate flowers such as *Leucas aspera, Ocimum canum* and *Dolichos biflorus* belong to the closed type and they are useful chiefly for nectar although *Sesbania grandiflora* and *Ocimum canum* are also equally useful for pollen. These observations generally confirm Parker's (1926).

Flowers belonging to the open and spike types are generally pollen species only. *Psidium guajava* and *Leucaena glauca,* for example, belong to the open type while *Sorghum vulgare* and *Pennisetum typhoides* belong to the spike type. The method of collecting pollen from these types vary. In gathering pollen from flowers of the open type, the bees bite the anthers with their mandibles and pull them towards their bodies with their forelegs while at the same time they run rapidly over the flowers packing the pollen in the pollen baskets. A slightly different method of gathering pollen from *Cereus (peruvianus ?)* which belongs to the tubular type has been noticed. In these flowers the bees first get to the bottom and walk upwards along each filament of the stamens towards the tip where the anthers are fixed. Here the bees bite the anthers and at intervals suspend themselves in the air for a few seconds collecting the pollen grains in the pollen baskets. On the spike type of flowers, the bees were seen to run over them from bottom to top and then rise in the air packing the pollen into the pollen baskets. The above observations appear to be generally in conformity with Parker's (1926).

Flowering periods. The present study was commenced in August 1937 and extended almost to the end of July 1938 and so covers a period of about 12 months. During this period, pollen study was carried out almost at weekly intervals except during six weeks. Even on these six occasions the interval between two days of study did not exceed a fortnight. It is well known that the flush of flowers of almost all South Indian flora lasts for more than a fornight and it may, therefore, be taken that this investigation covers almost all flora available in the vicinity of the apiary.

In Table II the number of species in flower during the respective months is summarised.

TABLE II
Number of species in flower during the respective months

Months		No. of species		
		Nectar	Pollen	Dual purpose
January	...	11	4	3
February	...	6	1	2
March	...	3	1	2
April	...	5	5	5
May	...	5	5	5
June	...	4	3	2
July	...	4	1	1
August	...	3	2	1
September	...	3	6	2
October	...	8	12	2
November	...	10	13	3
December	...	11	11	3
	Total No. of species	15	17	6

It will be seen from Table II that during October to January the largest number of species are in flower. Again in April-May there is a second season. There appears to be a dearth of pasturage during March and June-September. Particularly the month of August seems to be a very "dry" month. Such species as *Cocos nucifera, Tridax procumbens* and *Antigonon leptopus* are in flower almost throughout the year. But no pollen species are in bloom all round the year. Other species like *Moringa oleifera,* cotton and *Psidium guajava* are in flower during two seasons in the year. Such species, however, are only few. In fact out of 15 nectar species only three, and out of 17 pollen species only four, have two flowering seasons.

Bees were examined for pollen at hourly intervals so as to obtain information as to the hours from which or up to which particular species were visited by bees for one purpose or another. The information so obtained has been presented in Table IV. In Table III the total number of species which are utilised by the bees for pollen or for nectar at the various hours of the day when such species are in flower is furnished.

TABLE III
Number of species visited by bees at various hours of the day.

Hour		No. of species		
		Nectar	Pollen	Dual purpose
5 a. m.	...	4	4	3
6 ,,	...	5	6	4
7 ,,	...	6	9	5
8 ,,	...	8	13	6
9 ,,	...	12	15	6
10 ,,	...	13	16	6
11 ,,	...	13	14	3
12 ,,	...	11	12	3
1 p. m.	...	10	6	3
2 ,,	...	10	3	2
3 ,,	...	8	1	2
4 ,,	...	7	...	3
5 ,,	...	4	...	2
6 ,,	...	3	...	2
7 ,,	...	3	...	2
Total No. of species		15	17	6

TABLE IV. SPECIES OF PLANTS VISITED BY BEES

References: w—white; y—yellow; p—pink; b—blue; r—rose; rd—red; g—grey; c—closed type; o—open type; t—tubular type; s—spike type; x—nectar; —pollen; x̲ nectar and pollen.

Name of Plant	Floral colour	Flower type	Months of flowering												Time of visit: a. m.								p. m.						
			January	February	March	April	May	June	July	August	September	October	November	December	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7
Nectar Species																													
1. *Justicia tranquebariensis*	w	c	x									x	x	x					x	x	x	x	x	x	x	x	x		
2. *Tridax procumbens*	y	t	x	x	x	x	x	x	x	x	x	x	x	x						x	x	x	x	x	x	x			
3. *Ipomoea batatas*	w	t	x	x												x	x	x	x	x									
4. *Benincasa cerifera*	y	t	x									x	x	x				x	x	x	x								
5. *Cucurbita maxima*	y	t	x									x	x	x	x	x	x	x	x	x									
6. *Euphorbia heterophylla*	r	t	x	x										x			x	x	x	x	x								
7. *Leucas aspera*	w	c	x									x	x	x							x	x	x	x	x	x			
8. *Gossypium sp.*	y	t	x	x		x	x							x					x	x	x	x	x	x	x	x			
9. *Moringa oleifera*	w	o	x	x	x				x	x					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
10. *Antigonon leptopus*	r	o	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
11. *Coriandrum sativum*	w	o	x										x	x				x	x	x	x	x	x	x					
12. *Tamarindus indica*	y	o				x	x	x	x						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
13. *Merremia dissecta*	w	t				x	x	x			x	x	x								x	x	x	x					
14. *Ipomoea purpurea*	b	t										x	x	x					x	x	x	x							
15. *Dolichos biflorus*	y	c											x	x					x	x	x	x	x	x	x				
Pollen species																													
16. *Ocimum canum*	w	c	–							–	–	–	–	–					–	–	–	–	–	–					
17. *Leucaena glauca*	w	o	–			–	–	–			–	–		–	–	–	–	–	–	–	–	–							
18. *Psidium guajava*	w	o	–			–	–					–	–	–	–	–	–	–	–	–	–	–							
19. *Argemone mexicana*	y	o	–	–								–	–	–						–	–	–	–						
20. *Calophyllum inophyllum*	w	o			–	–				–	–	–	–				–	–	–	–	–								
21. *Cereus peruvianus (?)*	w	o				–	–				–	–			–	–	–	–	–										
22. *Peltophorum ferrugineum*	y	o				–	–	–								–	–	–	–	–	–	–	–	–					
23. *Poinciana regia*	rd	o				–	–	–											–	–	–	–	–	–					
24. *Tribulus terrestris*	y	o									–	–	–	–				–	–	–	–	–							
25. *Saccharum officinarum*	w	o									–	–	–					–	–	–	–	–							
26. *Trichodesma indicum*	p	o										–	–	–			–	–	–	–	–								
27. *Cleome viscosa*	y	o										–	–	–			–	–	–	–	–	–	–						
28. *Lagasca mollis*	w	o										–	–	–						–	–	–	–	–	–				
29. *Ricinus communis*	w	o										–	–	–				–	–	–	–	–	–						
30. *Tragus biflorus*	w	s											–					–	–	–	–	–							
31. *Sorghum vulgare*	y	s											–	–	–	–	–	–	–	–									
32. *Pennisetum typhoides*	g	s											–	–		–	–	–	–	–									
Pollen and nectar species																													
3. *Ipomoea carnea*	w	t	x̲			x̲	x̲	x̲			x̲	x̲	x̲	x̲		x̲	x̲	x̲	x̲	x̲									
34. *Sesbania grandiflora*	w	c	x̲	x̲									x̲	x̲	x̲	x̲		x̲	x̲	x̲						x̲	x̲	x̲	x̲
35. *Cocos nucifera*	y	o	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲			–	–	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲			
36. *Cucumis sativus*	y	t			x̲	x̲	x̲											x̲	x̲	x̲	x̲	x̲	x̲						
37. *Odina wodier*	y	o				x̲	x̲								x̲	x̲	x̲	x̲	x̲	x̲									
38. *Opuntia dillenii*	y	o				x̲	x̲								x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲	x̲

It will be seen from table III that the greatest number of species are visited by bees between 9 and 10 a. m. either for nectar or for pollen. The number of species that are so visited increases as the day advances from 5 a. m. to about 10 a. m. and then steadily falls. Out of a total of 15 nectar species only three are visited by bees throughout the day and out of six species serving a dual purpose only one is similarly utilised. There is not a single pollen species from which pollen is collected by bees throughout the day. Invariably most of the pollen species are not visited by bees in the afternoon. Although pollen is available in the flowers after certain hours, bees were observed not to gather them after those hours. This may perhaps be due to some changes in the pollen grains themselves on account of environmental factors. What exactly those factors are, it is at present unknown.

Discussion. The pollen study of ascertaining bee pasturage which has not so far been attempted in India, indicates that this method is a very useful approach for collecting the list of bee flora of each locality. The method gives the clue as to where exactly to look for the bees in the field. The usefulness of this method is demonstrated by the fact that 20 species hitherto not reported in India were discovered as being useful. It is here that the personal prejudices of the workers as to the usefulness or otherwise of particular species are eliminated and the results arrived at are checked by visiting the plant sources in the field. By this method a confirmation as to the utilization of the species by the bees for one purpose or another is readily obtained with information as to the time of visit by bees. Such weeds as *Leucas aspera*, *Tribulus terrestris* and *Ocimum canum* were (at least by the present author) least suspected pasturage crops, and a study of pollen grains has definitely indicated that even weeds which are ordinarily eradicated by agriculturists as being a nuisance, have their own status in providing bee pasturage.

Generally there are two seasons in the year when plants are in bloom when the apiculturist can expect a surplus crop of honey. One season commences from November and continues up to the end of January while the other season commences in March and lasts only for about two months. The former season comprises a large number of annuals like cotton and the cucurbitaceous plants, while in the latter season chiefly *Tamarindus indica* and the second crop of flowers in cotton are useful. Most of the species are visited by bees in the forenoon only.

That the proximity of flowers facilitates the performance of a larger number of trips by bees in a given interval of time is easily recognised. This is no mean advantage for the apiculturist in getting a surplus crop of honey. While records about the range of flight of some of the European bees indicate that bees visit flowers situated even two miles away from the apiary (Eckert, 1933), Ramachandran (1937) reports that in South India the range of flight of Indian bees is only about three furlongs. The present study, however, indicates that bees fly a distance of even six furlongs provided a good pasturage, for example, *Cucumis sativus*, is available. Although the range of flight may be extensive, it should be emphasized that the location of nectar species situated far away from the apiary is uneconomic. Of the 38 species recorded in the present study, excepting one (*Cucumis sativus*) all else were situated within a radius of 500 yards from the apiary.

The species of plants now found useful to bees may be classified as in Table V.

TABLE V

Status of the species in the field of agriculture.

Class	Nectar species		Pollen species		Dual purpose	
	Number	Percentage of total	Number	Percentage of total	Number	Percentage of total
Weeds ...	4	27	7	41	1	17
Cultivated :—						
Ornamental plants	3	20	2	13	1	17
Economic plants	6	40	4	23	1	17
Trees	2	13	4	23	3	49
Total	15	100	17	100	6	100

From Table V it will be seen that of the nectar species 40 per cent. are cultivated plants of economic importance while weeds and trees contribute 27 and 13 per cent. respectively. On the other hand cultivated plants are less useful for pollen, and the largest share (41 per cent.) of the pollen species is provided by weeds only. Next in importance, the cultivated plants contribute a total of about 36 per cent. of the pollen species followed by trees. Forty-nine per cent. of the species serving a dual purpose are trees.

Mention may be made of the most important species useful for bees:—

Nectar species: *Tamarindus indica*, cotton, *Cucumis sativus*
Pollen species: *Sorghum vulgare*, *Pennisetum typhoides*, *Psidium guajava*, *Cereus peruvianus* (?)

The above species have made themselves important by sheer numbers, that is by the availability of a large population of flowers over a compact area of field. Most of these are cultivated plants. It may be concluded, therefore, that relatively speaking, cultivated plants are more economic from the apiculturist's point of view than wild weeds. It is by no means the intention to under-estimate the value of some weeds. Especially in November—January season a large majority of the pollen species comprise of weeds only and but for them, there would have been a dearth of pasturage during these months.

Summary and Conclusions. In respect of information so far available in India as to bee pasturage, the method of ascertaining species has been confined to locating in the field the flowers actually visited by bees. Key pollen slides from known plants growing in the locality under study have been prepared in methyl green glycerine jelly, and the pollen actually brought by bees, and the pollen adhering to the body of nectar gatherers have been identified. A list of 38 species useful for nectar, for pollen, and for both has been obtained and as many as 20 plants in the list are reported for the first time in India. Analyzing the colour of the flowers visited by bees, it is observed that a majority of bee flora possess white and yellow flowers. The shape of the flowers in relation to their utility by bees is indicated, and the method of collecting pollen from the various floral types is discussed. There are two seasons in the year during which plants come to bloom, one in October-January and the other in April-May, the former comprising mostly of weeds and annuals, and the latter of perennials. A majority of flowers are visited by bees in the forenoons only. Although pollen is available after certain hours, bees are found not to gather them, and why this is so, it is not at present definitely known.

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APPENDIX

EXTERNAL MORPHOLOGY OF THE POLLEN GRAINS OF THE BEE FLORA

Note :— The description of pollen grains relate to specimens mounted in methyl green glycerine jelly. In the case of spinous pollen grains, the diameters of the grains furnished exclude the length of the spines. For the sake of convenience in reference the species are grouped according to their families and arranged alphabetically.

Acanthaceae.

1. *Justicia tranquebariensis*, L. f. (Fig. 1)—Egg shaped with poles more flattened. 34·5—20·7 μ. Smooth and clear with one furrow.

Anacardiaceae.

2. *Odina wodier*, Roxb.—Yellow. Spheroidal. 20—21 μ. Exine 3·5 μ. Surface smooth and clear. Three furrows each containing one germ pore. Furrows gape widely in stained specimens giving almost a triangular appearance.

Boraginaceae.

3. *Trichodesma indicum*, R. Br. (Fig. 2)—Small and generally spheroidal. 20—21 μ. Three spindle shaped furrows.

Cactaceae.

4. *Opuntia dillenii*, Haw.—Yellowish white. Spheroidal. 120 μ. Seven to nine pores, dia. 25 μ. Surface finely pitted.

Reported previously by Ramachandran (1937).

5. *Cereus (peruvianus ?)* (Fig. 3).—White. Spheroidal. 69 μ. Three spindle shaped furrows. Surface finely frothy. Exine thin and striated.

Previously reported by Ratnam (1938). There is some doubt regarding the nomenclature of this plan Confirmation is being made.

Capparidaceae.

6. *Cleome viscosa*, L. (Fig. 4).—Yellow. Spheroidal. 27—30 μ. Furrows wide and spindle shaped. Exine striated and rather thick. Surface smooth and clear.

Compositae.

7. *Lagasca mollis*, Cav.—Whitish. Spheroidal. 24—31 μ. Spines 3 μ long and do not take in stain. Surface clear. Reported previously as a pollen source by Ramachandran (1937).

8. *Tridax procumbens*, L.—Spheroidal and spinous. 24—28 μ. Spines 3·5—5 μ long and distributed about 4 μ apart and do not take in stain. A few large pores about 6 μ in diameter. Exine faintly striated.

Convolvulaceae

9. *Ipomoea batatas*, L.—Spinulose (Gamble, 1923). Spheroidal 120 μ. Spines 10 μ long and 10 μ apart, and do not take in stain.

10. *Ipomaea carnea*, Jacq. (Fig. 5).—White. Spheroidal. 75 μ. Spinous. No uniformity in distribution of spines. A few spines appear a little hooked at the tip. Spines do not take in stain.

11. *Ipomoea purpurea* Roth.—Exactly like *I. carnea*. 116 μ.

12. *Merremia dissecta*, Hall. f.—Spheroidal. 83 μ. Exine striated and 6—8 μ thick. Surface finely frothy. Three furrows spindle shaped. No furrows.

Cucurbitaceae.

13. *Benincasa cerifera*,—Savi.—Nearly spheroidal. 65 μ. Surface finely reticulate.

14. *Cucumis sativus*, L.—Yellow. Spheroidal. 42—45·5 μ. Surface smooth and clear. Three furrows.

15. *Cucurbita maxima*, Duch.—Spheroidal. 158 μ. Spinous. Spines 7—10 μ long. Distribution of spines not regular. Seven to nine pores diameter 25—35 μ.

Ramachandran (1937) refers to cucurbitaceous plants as being useful for bees.

Euphorbiaceae.

16. *Euphorbia heterophylla*, L. (Fig. 6).—Mounted specimens three lobed. 31—35 μ. Exine stout and striated. Surface possesses elaborate sculpturing.

Georgia (1914) states that honey gathered from the flowers of this plant is "acrid" and emetic and unfit for use. This does not seem to obtain confirmation under South Indian conditions.

17. *Ricinus communis*, L. (Fig. 7).—Spheroidal or nearly so. 28 μ. Exine 3·5 μ Three furrows separate the exine which have knob-like ends. Finely reticulate surface.

Graminae.

18. *Tragus biflorus*, Schult.—Light yellow. Spherical. 24—30 μ. Surface granular. Single germ pore diameter 3 μ.

19. *Sorghum vulgare*, Pers.—Yellow. 45—48 μ. Spheroidal. Single germ pore 3·5 μ diameter. Surface smooth and finely granular. Exine slightly striated

Previously reported by Ramachandran (1937).

20. *Pennisetum typhoides*, Stapf & Hubbard—Grey. Mounted grains examined within a week after mounting do not appear perfectly spheroidal. Diameter varies from 41·4—34·5 μ. Surface coarsely granular.

Previously reported by Ramachandran (1937).

21. *Saccharum officinarum*, L.—Spheroidal. 31—34·5 μ. Surface smooth and lightly granular. Exine thin and striated.

Guttiferae.

22. *Calophyllum inophyllum*, L. (Fig. 8).—Bright yellow. Spheroidal. 38 μ Exine 3·5 μ and striated. Surface smooth and clear.

Labiatae.

23. *Leucas aspera*, Spr.—Spindle shaped. Polar diameter 21—24 μ. Surface smooth and clear. Three furrows.

24. *Ocimum canum*, Sims (Fig. 9).—Spheroidal. 55—60 μ Six furrows. Surface characteristically reticulate.

Leguminosae.

25. *Peltophorum ferrugineum*, Benth.—Spheroidal. 48 μ. Reticulate almost amounting to pitted appearance. Three furrows.

Previously reported by Ramachandran (1937).

26. *Poinciana regia*, Boger.—Spheroidal. 48—55 μ. Three furrows. Exine 6·5 μ and striated. Surface clear and reticulate.

Previously reported by Ramachandran (1937).

27. *Tamarindus indica*. L.—Spheroidal. 34·5 μ. Exine 2 μ. Surface smooth Three furrows.

Previously reported by Ramachandran (1937) and Ratnam (1938).

28. *Leucaena glauca*, Benth.—Almost spheroidal. 41—43 μ. Surface smooth exine thick. Faintly frothy. Three furrows.

29. *Dolichos biflorus*, L. (Fig. 10).—Egg shaped with one pole rather pointed The length from pole to pole varies rather widely in mounted grains from 60-85 μ and width from 45—60 μ. Three furrows. Fine bristles scattered over the surface.

30. *Sesbania grandiflora*, Pers. (Fig. 11).—Spheroidal. 34·5 μ. Surface smooth and slightly granular.

Malvaceae.

31. *Gossypium indicum and G. hirsutum.*—Spheroidal or nearly so. Spinous. 95—97 μ. Spines 7 μ long and take in stain.

Previously reported by Ramachandran (1937) and Ratnam (1938). Banerji (1929) has studied in detail the pollen of the various *Gossypium* species.

Moringaceae.

32. *Moringa oleifera*, Lam. (Fig. 12).—Spheroidal. 30—38 μ. Three furrows each containing a germ pore. Surface clear and smooth.

Reported previously by Ramachandran (1937).

Myrtaceae.

33. *Psidium guajava*, L. (Fig. 13).—Very small. From the polar view almost exactly triangular. Width 12—16 μ. Surface smooth and clear. Exine striated. Three linear furrows.

Previously reported by Ramachandran (1937) and Ratnam (1938).

Palmaceae.

34. *Cocos nucifera*, Linn.—Mounted specimens irregularly round with flattened margin at one portion, having one furrow. 35—41 μ. Surface smooth and exine thick.

Ramachandran (1937) states that this is a useful pollen source during May and June. Narayana (1937) and Patel (1938) have reported that coconut flowers are always visited by bees.

Papaveraceae.

35. *Argemone mexicana*, L. (Fig. 14).—Spheroidal. 34·5 μ. Exine thin. Surface smooth and clear. Three furrows gape widely.

Polygonaceae.

36. *Antigonon leptopus*, Hk & A.—Almost spheroidal. 52 μ. Texture granular. Surface characteristically pitted.

Ramachandran (1937), Ratnam (1938) and Venkatasubbayya (1938) have all reported about this plant previously.

Umbelliferae.

37. *Coriandrum sativum*, L. (Fig. 15).—Egg shaped with flattened poles. Length 32 μ and width 10·5 μ. At the equatorial region, the exine has a ridge running all round. Surface clear and smooth.

Ramachandran (1937) states that Coriander is also suspected to be a pasturage crop but that its status is not known.

Zygophyliaceae.

38. *Tribulus terrestris*, L. (Fig. 16).—Spheroidal. 40—45 μ. No furrows. Surface characteristic with fine reticulations. The lacunae are not divided by solid continuous ridges, but only coil-like partitions which under the lower powers of the microscope appear like a chain of dot-like structures. Lacunae are clear and contain germ pores.