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H. A. Allard
USDA

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H. A. ALLARD

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SOME EXPERIMENTAL OBSERVATIONS CONCERNING THE BEHAVIOR OF VARIOUS BEES IN THEIR VISITS TO COTTON BLOSSOMS. I

H. A. ALLARD

U. S. DEPARTMENT OF AGRICULTURE

IN the past a great deal of experimental work has been carried on to determine how flowers attract insects. The conclusions reached have been various and have served to provoke lively discussions as to the relative importance of the visual sense and the olfactory sense in guiding insects to flowers.

Beginning with the notable work of Sprengel, an extensive literature has developed attempting to explain the relative importance of colors and odors in attracting insects to flowers. The conclusions reached have served to provoke lively discussions as to the relative importance of the visual and olfactory sense in guiding insects to flowers. Herman Müller, Delpino, L. Errara, Lubbock, Knuth and others firmly supported the view that flowers advertised their location to passing insects by their conspicuous colored portions and considered odors of only secondary importance. In 1879 Gaston Bonnier advanced the opinion that colored petals were of slight importance in attracting insects to flowers. Later, after much experimenting, Felix Plateau promulgated his extreme views that the colored structures of blossoms were of practically no use as a means of attracting insect visitors, but that odors were the chief means by which bees and other insects were led to find blossoms. Plateau radically expressed himself as follows:

> Dans les rapports entre les insectes fécondateurs et les fleurs entomophiles la coloration plus au moins vive des organes floraux n'a pas le rôle prépondérant que Sprengel, H. Müller et leurs nombreux adeptes lui ont attribué. Toutes les fleurs de la nature pourraient être

vertes comme les feuilles sans que leur fécondation pas les insectes fut compromise. L'odorat si développé chez la plupart des insectes loin d'être un facteur accesoire est vraisemblement le sens principal qui leur fait découvrir les fleurs renfermant du pollen ou du nectar.[1]

It is pretty generally conceded, however, that the corolla of flowers and many other conspicuous floral structures possess a very important function in serving to attract various insects. Many odors likewise serve the same purpose, even to a very considerable extent, as shown by the interesting experiments of Plateau and others.

In connection with experimental cotton breeding investigations in northern Georgia, the writer has had occasion to give considerable attention to the visits of bees and other insects among cotton blossoms in this region. The large number of certain species of bees regularly visiting cotton blossoms and the ease with which observations could be made in the field led the writer, during the summer of 1910, to make a series of experiments in order to learn more definitely, if possible, just how cotton blossoms attract bees, whether mainly through the visual or the olfactory sense.

These experiments were made at the beginning of the blooming season when blossoms were very scarce and bees very numerous. The first experiment was begun in the forenoon of July 26, and others followed throughout July and early August. Each day the period of observations began at eight or nine o'clock and terminated about twelve or one o'clock, at which time the blossoms were beginning to close and bee visitors were much less frequent. For each test a period of half an hour or an hour was usually allowed, thus making the number of insect visits sufficiently numerous for valid conclusions.

By far the majority of bee visits were made by *Melissodes bimaculata,* although other species of *Melissodes* were no doubt casual visitors. The big wasp (*Elis plumipes* Drury) and a *Bombus* or an *Entechnia* occasionally

[1] "Les Insectes et la Couleur des Fleures," *L'Année Psychologique,* 13, 1907.

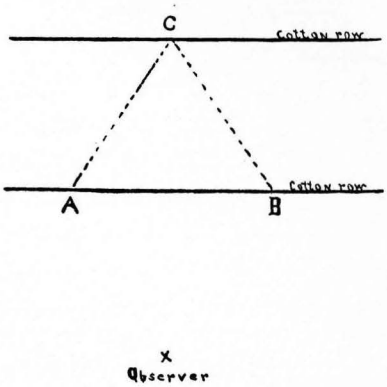
appeared. Later in the season the visits of the extremely common *Melissodes bimaculata* suddenly fell off, and the common honey bee (*Apis mellifica* L.) became more frequent in its visits. For reasons rather difficult to explain, honey bees at the beginning of the experiments were very rare visitors.

The observations and conclusions apply mainly to the behavior of species of *Melissodes*. A count was made of every bee which gave definite evidence that it had perceived the blossoms under observation. These records also included the number of times bees actually alighted upon or entered them. Many bees which do not enter a blossom frequently indicate that they have perceived it by a sudden pause or quick turn toward it momentarily. The manner and thoroughness of these inspections by bees ranges from the merest swerve and hesitation in their flight to a close and scrupulous scrutiny of the blossoms from all sides as they hover over them. At all times it is evident that the actual number of entrances into a blossom is small when compared with the number of inspections without entering. Just why so many bees inspect a normal blossom and refuse to enter is not clear. This is more particularly the rule with species of *Melissodes*.

It is not long till one can readily identify the more important bee visitors within certain limits by their different flight characteristics. Bees of the species *Melissodes bimaculata* appear as black, swift-flying, nervous bees, and are readily determined by their hasty movements among the cotton plants. The species of bumble bees, the common honey bee and *Elis plumipes* are more labored in their flights from blossom to blossom. The wasp, *Elis plumipes,* usually flies very slowly and seems to find it necessary to alight on a blossom in order to inspect it to advantage.

At the beginning of the experiments three blossoms were arranged in such a way as to form a triangle were they connected by straight lines. In some of the

later tests the blossoms were arranged in a line on the same row of cotton. When the triangular arrangement was followed, the points (*a*) and (*b*) were on plants in the same row and about four feet apart. Point (*c*) was situated on the next row back, equally distant from (*a*) and (*b*). The writer was concealed in the cotton directly in front of these points so that each could be kept readily under observation at all times (see Fig. 1). In each test



the only changes made were concerned with the blossoms at the points in question. One blossom at least in each experiment served as a control. See the accompanying triangular diagram.

Experiment No. 1.—July 26. Time of observation, one hour—from 9 to 10 A.M.

At (*a*) a normal blossom was growing *in situ* as a control.

At (*b*) a normal blossom was growing *in situ* as a control.

At (*c*) petals only of a blossom were carelessly pinned to a stem.

An *Elis plumipes* once alighted on the petals of (*c*), but immediately discovered the deception and flew away. The species of *Melissodes* in no instance alighted. These bees, it would seem, possess rather keen discerning powers, since without alighting they quickly detect the difference between a normal and a mutilated flower. In many instances, however, they inspect very carefully

a suspicious blossom before passing on. From this test it is evident that the petals alone, as used at (*c*), were quite as efficient in inviting inspection as the normal blossoms themselves. The blossom at (*b*) received fewer inspections, probably because it was less readily perceived among the leaves which nearly surrounded it.

The bee visits were distributed as follows:

DATA FOR EXPERIMENT No. 1

Points of Triangle	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	81	77	1			3	6	3	1			2
(*b*)	44	44					4	4	0			
(*c*)	82	81	1				0	0	0			

Experiment No. 2.—July 26. Time of observation one half hour, from 10 minutes past 10 to 10:40 A.M. Blossoms in the triangular arrangement as before. See diagram.

At point (*a*) same blossom with petals removed.

At point (*b*) same blossom entire as a control.

At point (*c*) petals alone as in preceding experiment.

DATA FOR EXPERIMENT No. 2

Points of Triangle	Total Inspections	Distribution by Species					Total Entrances	Distribution of Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	4	4					0					
(*b*)	50	50					5	5				
(*c*)	62	62					0	0				

The removal of the corolla of (*a*), which in the past experiment received 81 inspections, reduced the number of inspections at once to 4 as compared with 62 inspections of the detached petals at (*c*).

Exactly similar results were obtained by Darwin in

his experiments with *Lobelia erinus*. He says: "I cut off the petals of some and only the lower striped petals of others and these flowers were not once again sucked by the bees, although some actually crawled over them. The removal of the two little upper petals alone made no difference in their visits."

Experiment No. 3.—July 26. Time of observation one half hour, from 10:40 to 11:10 A.M. Blossoms in the triangular arrangement.

At point (*a*) 3 petals are replaced loosely.

At point (*b*) same blossom entire as before. Control.

At point (*c*) petals alone as in preceding experiments.

DATA FOR EXPERIMENT NO. 3

Points of Triangle	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	53	51			2		0					
(*b*)	51	50			1		1				1	
(*c*)	67	65			2		0					

With these petals now carelessly affixed to the blossom at (*a*) from which the corolla had been entirely cut away, the number of inspections is at once as frequent as for the control at (*b*). It appears that color and texture more than normal form and arrangement first direct the bees to inspect the blossoms.

Experiment No. 4.—July 26. Time of observations one half hour, from 11:15 to 11:45 A.M. Blossoms in the triangular arrangement with the following change from the preceding experiment.

At (*a*) cloth petals of an artificial rose are carefully arranged and pinned in position to simulate an open cotton blossom. The color of those petals approximated the creamy yellow of a natural cotton blossom; the texture, however, was very different.

At (*b*) control. Same blossom entire as in the preceding experiment.

DATA FOR EXPERIMENT NO. 4

Points of Triangle	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	6	6					0					
(*b*)	48	45			1	2	9	7				2
(*c*)	65	62			1	2	0					

At (*c*) control. Petals only as in the preceding experiment.

Bees have been very little attracted by the artificial cloth petals at (*a*). Although the color is not precisely that of a cotton blossom, several bees gave evidence of having perceived them. The texture, which is that of coarse meshed cloth, is quite unlike that of cotton petals, however, and may have been readily perceived as unreal by the bees. The few inspections were without doubt invited by the color of the artificial petals, since no odors could be considered operative unless of a repellent nature.

Experiment No. 5.—July 26. Time of observation one half hour, from 11:45 to 12:15 A.M. Blossoms in the triangular arrangement with the following changes:

At (*a*) five cotton petals (normal number) are carelessly placed over the artificial cloth petals.

At (*b*) control. Same blossom entire as in the preceding experiments.

At (*c*) petals alone as in the preceding experiments.

DATA FOR EXPERIMENT NO. 5

Points of Triangle	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	48	45				3	1					1
(*b*)	44	43				1	7	7				
(*c*)	50	48	1			1	0					

It is now evident that all the blossoms serve equally well to invite inspection. It is plainly indicated that the artificial cloth petals could have possessed little or no repellent odor, although they received very few inspections in the experiment just preceding. It is not improbable that the different texture of the material revealed the artificial nature of the cloth petals to the bees.

Experiment No. 6.—July 27. Day cloudy, showery in forenoon, thus greatly interfering with frequency of visits. Blossoms in the triangular arrangement.

At (*a*) control. A normal blossom pinned in position.

At (*b*) control. A normal blossom growing *in situ.*

At (*c*) a single petal pinned to a stem.

Observations were begun at 9:00 A.M., but rain intervened at 9:15. A single inspection was recorded for (*c*).

Observations were again begun at 10:25, lasting for one half hour until 11:05. The blossoms were arranged in the triangle as follows:

At (*a*) control. A normal cotton blossom pinned in position.

At (*b*) control. A normal cotton blossom growing *in situ.*

At (*c*) a half opened bud simulated by pinning normal petals together, the calyx being represented by a portion of a green cotton leaf carefully wrapped around the base. In this way it was absolutely certain that no unaccustomed odors were introduced. This bud-like arrangement prevented all chances of examination of the inner details by bees until they had actually squeezed down between the petals.

DATA FOR EXPERIMENT NO. 6

Points of Triangle	Total Inspection	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Espilumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	48						2					
(*b*)	21						0					
(*c*)	47						1					

A record of the kind of bees was not accurately kept, but species of *Melissodes* were almost the only visitors. The blossom at (*b*) was less visible than those at (*a*) or (*c*), both of which were in plain view of each other. The blossom at (*b*) was not visible either from (*a*) or (*c*), so that many bees which inspected (*a*) and (*c*) frequently failed to perceive (*b*).

Experiment No. 7.—July 27. Period of observations one half hour from 11:08 to 11:38. Blossoms in the previous triangular arrangement changed as follows:

(*a*) Normal blossom used in the preceding experiment concealed by fastening the surrounding leaves in such a manner that the blossom would be visible only by bees passing directly over it.

(*b*) Control. Normal blossom growing in situ.

(*c*) Artificially constructed bud as used in latter half of experiment 6.

The inspections were as follows:

(*a*) Received a single inspection from a bee flying directly over.

(*b*) Received 12 inspections, two of these being entrances.

(*c*) Received 40 inspections, none being entrances.

Experiment 7 differs from experiment 6 in no particular whatever except in the change which has rendered the blossom at (*a*) invisible, except from a certain position. The number of inspections at (*b*) and (*c*) remained practically constant for each half-hour period. It is interesting to note, however, that (*a*), receiving 48 inspections in experiment 6, received but a single inspection in experiment 7. A change in surroundings which makes a blossom less visible to the visual sense of bee visitors at once decreases the number of inspections.

Experiment No. 8.—July 27. Time of observations ten minutes from 11:38 to 11:48 A.M. Blossoms in the triangular arrangement, with no change whatever from the preceding experiment except in making the blossom

at (*a*) again as visible as in experiment 7 by pushing aside the surrounding leaves.

(*a*) Is inspected 15 times, including one entrance.

(*b*) Is inspected 7 times, including two entrances.

(*c*) Is inspected 13 times with no entrances.

The blossom at (*a*) has now become as attractive to the bees as those at (*b*) and (*c*) which serve as controls.

Experiment No. 9.—July 27. Period of observation 15 minutes, from 10:50 A.M. until 12:05 P.M. Triangular arrangement as in preceding experiments with the following changes:

(*a*) Petals of (*a*) in experiment 8 are removed and artificial crêpe paper petals of nearly the same color are substituted.

(*b*) Artificial blossoms growing *in situ* as a control.

(*c*) Artificial floral structure used at (*c*) in experiments 7 and 8.

(*a*) Receives only two inspections.

(*b*) Receives 16 inspections, including two entrances.

(*c*) Receives 3 inspections, including one entrance.

The artificial nature of the paper petals at (*a*) was at once perceived by the bees in their passing flights. The few inspections noted were indicated by a momentary pause in flight quite unlike the more prolonged hovering movements over the blossom at (*c*).

Experiment No. 10.—July 27. Period of observations 20 minutes, from 12:05 P.M. to 12:25 P.M. The same triangular arrangement was used as before. The only change from experiments 8 or 9 consisted in placing three real cotton petals carelessly upon the paper petals at (*a*) in such a way that only part of the paper petals was concealed. Blossoms (*b*) and (*c*) were left unchanged.

(*a*) Receives 11 inspections.

(*b*) Receives 7 inspections, including one entrance.

(*c*) Receives 21 inspections.

Passing bees were at once led to inspect the real petals placed at (*a*), although these very imperfectly covered the artificial paper petals beneath. No very decided re-

pellent odors can be held to reside in the artificial paper petals which failed to attract passing bees when used alone.

Experiment No. 11.—July 27. Observations for this experiment continued 10 minutes, from 1:26 to 1:36 P.M. The triangular arrangement was used.

At (*a*) a single real cotton-blossom petal is pinned to a stem.

At (*b*) a cotton bud and calyx simulated by neatly wrapping a portion of a cotton leaf around the base of five real petals rolled together.

At (*c*) a normal open cotton blossom growing in situ as a control.

DATA FOR EXPERIMENT NO. 11

Points of Triangle	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Eltis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Eltis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	2	2										
(*b*)	8	8										
(*c*)	3	3										

The single petal at (*a*) is sufficient to invite the inspection of passing bees, although there is little more than a fraction remaining of the size and color of a normal open cotton blossom. The writer has observed that a partly opened bud, as represented at (*c*), appears to invite more frequent inspection and entrance than a fully expanded blossom which has been much oftener entered by bees. It is possible that bees in their entrances leave traces of odors which are detected by later visitors, causing them to pass on in search of fresher blossoms.

Experiment No. 12.—July 27. Period of observations one half hour, from 1:36 to 2:06 P.M. In this test, which practically duplicates experiment 11, two blossoms were used in the same row and on plants about three feet apart.

At (*a*) a single petal was pinned to a stem.

At (*b*) control. A normal cotton blossom *in situ* as grown.

The single petal at (*a*) received 16 inspections, some of which were very thorough, as a number of bees appeared to examine the petal intently from all sides. The control blossom at (*b*) received 26 inspections, including 8 entrances within. In both cases the visiting bees were all species of *Melissodes*.

Experiment No. 13.—July 27. Period of observations one half hour, beginning at 2:06 P.M. and ending at 2:36 P.M. Two blossoms were arranged in the same row as in the preceding experiment.

At (*a*) a perfect cotton blossom was pinned in the same relative position as the blossom at (*b*).

At (*b*) control. A perfect cotton blossom growing *in situ*.

The blossom at (*a*) received 7 inspections, including one entrance. The blossom at (*b*) received 12 inspections, including 5 entrances. Species of *Melissodes* were the only visitors.

Experiment No. 14.—July 28. Time of observations one half hour, from 9:15 to 9:45 A.M. Three blossoms were arranged on three consecutive plants in the same row. Throughout this series of experiments for July 28, these positions were unchanged. See the diagram.

At (*a*) control. A perfect cotton blossom pinned in position.

At (*b*) large blossom of a wild convolvulus (white with a deep purple throat) was pinned in position.

DATA FOR EXPERIMENT NO. 14

Points of Triangle	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Eltis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Eltis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	15	12				3	1					1
(*b*)	14	12				2	0					
(*c*)	14	11				3	0					

At (*c*) control. A perfect cotton blossom pinned in position.

Although strikingly unlike a cotton blossom in color and general appearance, the convolvulus blossom attracts attention quite as often. It is hardly to be expected that the bees would enter it as frequently as a cotton blossom, if at all, since it is a well-known habit of many bees to confine their visits pretty constantly at any one time to blossoms of the same species of plant. Especially has this been shown true for the honey bee by Hermann Müller and others. M. H. Mendleson, of California, affords an instance where a single colony out of 200 visited solely mustard flowers, while the rest gathered from sage blossoms alone.[2]

Experiment No. 15.—July 28. Time of observation one half hour, from 9:45 to 10:15 A.M. Blossoms arranged in the same row as before with the following changes:

At (*a*) petals removed from the blossoms of preceding experiment.

At (*b*) same white convolvulus blossom used in the preceding experiment.

At (*c*) control. Same cotton blossom of preceding experiment pinned in position.

DATA FOR EXPERIMENT NO. 15

Points of Triangle	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	0											
(*b*)	19	17				2	0					
(*c*)	20	20					0					

By the removal of the petals of a cotton blossom as at (*a*), the blossom no longer advertised itself to the attention of bees, as has been demonstrated in previous experiments. In the present test, although the white con-

[2] Mendleson, M. H., "Gleanings in Bee Culture," October, 1908, 36.

volvulus blossom had completely wilted and collapsed, its noticeable color alone continued to invite inspection by passing bees quite as often as the control blossoms at (*c*).

Experiment No. 16.—July 28. Period of observation one half hour, from 10:15 to 10:45 A.M. The three points in the preceding experiment were used as follows:

At (*a*) a single cotton petal was placed on the blossom of the preceding experiment, from which all the petals had been removed.

At (*b*) a single cotton petal was loosely pinned to a stem.

At (*c*) control. A normal cotton blossom pinned in a conspicuous position.

The blossom at (*a*) receives 8 inspections.

The petal at (*b*) receives 9 inspections.

The normal blossom at (*c*) receives 27 inspections with no entrances. All visitors were *Melissodes,* except a small bee which inspected (*c*).

As the blossom at (*c*) was conspicuous from all sides, the writer judged that this fact accounted for the much greater number of inspections given this blossom, since (*a*) and (*b*) were visible almost wholly from one side only. In the next experiment this question was further tested.

Experiment No. 17.—July 28. Period of observation one half hour, from 10:45 to 11:15 A.M. In this experiment the only changes from the preceding consisted in an interchange of material.

DATA FOR EXPERIMENT NO. 17

Points of Triangle	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	8	8					0					
(*b*)	22	21				1	0					
(*c*)	27	25				2	0					

At (*a*) single detached petal pinned to leaf stem.

At (*b*) control. Normal cotton blossom pinned in position.

At (*c*) the cotton blossom with its single replaced petal at (*a*) in preceding experiment.

In this experiment the more exposed position (*c*) appears to be of considerable advantage to a blossom located here, even though its normal appearance is greatly changed by mutilation. The general form and appearance of a cotton blossom, as a whole, does not appear to play a very important rôle in initiating the procedure of inspection by passing bees, since a single detached petal receives quite as many inspections as a normal blossom.

Experiment No. 18.—July 29. Observations continued one hour, from 8:20 to 9:20 A.M. In this experiment three blossoms were used, as in previous experiments, and arranged on consecutive plants in the same row. A blossom of an Asiatic cotton (*Hawasaki*) was compared with two ordinary American upland blossoms as controls.

(*a*) control. Normal American upland blossom pinned in position.

(*b*) *Hawasaki* blossom entire pinned in position.

(*c*) control. Normal American upland blossom pinned in position.

DATA FOR EXPERIMENT NO. 18

Points of Triangle	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Ellis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Ellis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	20	19		1			0					
(*b*)	14	12		1		1	0					
(*c*)	29	24		1	1	3	2				1	1

Experiment No. 19.—July 29. Observations continued one half hour, from 9:25 to 9:55 A.M.

(*a*) Control. Normal American upland blossom pinned in position.

(*b*) Control. Normal American upland blossom pinned in position.

(*c*) *Hawasaki* blossom entire (at *b*) in last experiment.

DATA FOR EXPERIMENT NO. 19

Position of Blossoms	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	11	8				3	0					
(*b*)	10	7			1	2	1				1	
(*c*)	3	2				1	0					

Experiment No. 20.—July 29. Observations continued one half hour, from 10:50 to 11:20 A.M.. Three blossoms arranged in the same row as for previous experiments.

(*a*) Control. Normal American upland blossom pinned in position.

(*b*) *Hawasaki* blossom entire at (*c*) in experiment 19.

(*c*) Control. Normal American upland blossom pinned in position.

DATA FOR EXPERIMENT NO. 20

Position of Blossom	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	20	8	1	1		10	3		1	1		1
(*b*)	10	8				2	0					
(*c*)	16	6		1	1	8	2	1				1

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Experiment No. 21.—July 29. Observations continued one half hour, from 1:30 to 2:00 P.M. Three blossoms arranged in the same row.

(*a*) Control. Normal American upland cotton blossom pinned in position.

(*b*) Control. Normal American upland cotton blossom pinned in position.

(*c*) *Hawasaki* blossom entire pinned in position.

DATA FOR EXPERIMENT NO. 21

Position of Blossom	Total Inspections	Distribution by Species						Total Entrances	Distribution by Species					
		Melissodes sp	*Elis plumipes*	Honey Bees	Butterfly	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Rutterfly	Bumble Bees	Unidentified Bees
(*a*)	12	10		2				1			1			
(*b*)	9	6		3				2			2			
(*c*)	11	8		2	1			2	1			1		

Experiments 18, 19, 20 and 21 are essentially similar, since in each a blossom of the Asiatic cotton, *Hawasaki*, is compared with American upland blossoms. The points of location of the blossoms were unchanged throughout, but the blossoms themselves were interchanged in order to check any advantage which might obtain from a particular position in the arrangement.

The *Hawasaki* blossom is smaller in size than the upland and much brighter yellow in color with conspicuous deep reddish purple petal spots inside. It was thought

that the behavior of visiting bees toward the American upland blossoms and the dissimilar Asiatic *Hawasaki* would perhaps serve to distinguish between the effects of color and form as compared with odor in inducing the visits of bees into cotton blossoms. Results indicate that the *Hawasaki* blossom, although quite unfamiliar to our native bees, is nearly as frequently inspected as our American upland blossoms.

From the readiness with which bees are led to inspect the *Hawasaki* blossoms, single detached cotton petals and the white convolvulus blossom even after it had become greatly wilted and collapsed, it is evident that they are not at first sight led to distinguish cotton blossoms from other blossoms, etc., by their characteristic form and color alone. Only by a nearer approach does the process of inspection become more discriminating in its nature with regard to the kind of blossom.

Experiment No. 22.—July 29. Period of observation one half hour, from 2:10 to 2:40 P.M. Two blossoms were used on two adjacent plants in the same row and similarly exposed.

(*a*) Blossom of American upland which had opened the day before and in consequence had become deep reddish purple in color.

(*b*) Control. Normal, recently opened cream-colored blossom of same variety.

DATA FOR EXPERIMENT NO. 22

Position of Blossoms	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Ellis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Ellis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	12	11				1						
(*b*)	26	24			2		1	1				

Some time after midday, depending upon prevailing weather conditions, the recently expanded cream-colored cotton blossoms of that day slowly begin to close again and assume a reddish color, which by the second day is a

deep reddish purple. In connection with previous observations it was noted that those older blossoms appeared to possess little attractiveness for bees. The test was designed to reveal any differences which might serve to indicate to the bees that the purple blossom had passed the stage of usefulness to them. Although bees may in their flight indicate that the red blossom has been perceived, the inspections are usually far briefer than with the newly open blossoms of the same day. Rarely does a bee noticeably check its flight to hover over the red blossoms in the careful manner that it usually inspects those newly opened blossoms which are unchanged in color. The marked difference in color or some peculiarity of odor seems to inform the bees that an old blossom has nothing to offer them, since the pollen has been scattered and nectar is no longer secreted.

Experiment No. 23.—July 30. Time of observation one half hour, from 9:00 to 9:30 A.M. Three blossoms are arranged in the same row in equally exposed positions, as in previous experiments.

(*a*) Control. Normal upland cotton blossom pinned in position.

(*b*) Control. Normal upland cotton blossom pinned in position.

(*c*) Normal upland cotton blossoms with a drop or two of honey at base of petals within.

DATA FOR EXPERIMENT NO. 23

Position of Blossoms	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	7	5			1	1	1				1	
(*b*)	6	2		1	2	1	1				1	
(*c*)	7	4		1	1	1	2	1		1		

The presence of a small quantity of honey in the blossom at (*c*) has not noticeably increased the number of entrances into it.

The single *Melissodes* which entered the blossom at (*c*) gave evidence of its appreciation of the honey which it discovered by stubbornly refusing to leave the blossom until rather violently brushed away.

Experiment No. 24.—July 30. Time of observations one half hour, from 11:00 to 11:30 A.M. Three blossoms arranged in same row. This experiment is an exact repetition of the preceding.

(*a*) Control. Normal upland cotton blossom pinned in position.

(*b*) Control. Normal upland cotton blossom pinned in position.

(*c*) Normal blossom with honey at base within.

DATA FOR EXPERIMENT NO. 24

Position of Blossoms	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	26	16	2	4	3	1	7	3	2		2	
(*b*)	33	22	2	5	3	1	8		2	3	3	
(*c*)	14	9	1	3	1		0					

Experiment No. 25.—July 30. Time of observations one half hour, from 11:30 to 12:00 A.M. Three blossoms arranged in the same row.

(*a*) Normal cotton blossoms pinned in position as a control.

(*b*) Normal cotton blossom with honey added at base of petals within.

DATA FOR EXPERIMENT NO. 25

Position of Blossoms	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	22	16		6			4			4		
(*b*)	19	14		4	1		1			1		
(*c*)	15	10		3	2		2			1	1	

(*c*) Normal cotton blossom pinned in position as a control.

During the forenoon the weather was dull, so that bees were less frequent in their visits.

Experiment No. 26.—August 1. Period of observations one half hour, from 9:00 to 9:30 A.M. Blossoms arranged in same row as follows:

(*a*) Normal cotton blossom with honey at base of petals within.

(*b*) Normal cotton blossom pinned in position as a control.

(*c*) Normal cotton blossom pinned in position as a control.

DATA FOR EXPERIMENT NO. 26

Position of Blossoms	Total Inspections	Distribution of Species					Total Entrances	Distribution of Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	26	22	1	1	1	1	0					
(*b*)	27	22		2	1	2	1			1		
(*c*)	20	17			1	2	1				1	

Experiment No. 27.—August 1. Period of observations one half hour, from 9:00 to 9:30 A.M. Blossoms are arranged in the same row.

At (*a*) an unmutilated cotton blossom was pinned in position. Portions of cotton leaves were carefully cut out and fastened outside and within the blossom in such a manner as to extend just to the margin of the petals on both sides. In this way none of the yellow color of the petals remained visible. The stamen tube, pistil, etc., projected as in a normal blossom. The blossom was practically without petals, since these were not visible, although such odors as they may have possessed could still diffuse around the blossom. A drop or two of honey was also added at the base of the petals within in order to make certain that agreeable odors were present, since

these must now necessarily constitute the sole allurement.

At (*b*) normal blossom pinned in position. The tips of the petals were lightly smeared with honey.

At (*c*) control. Normal cotton blossom pinned in position.

DATA FOR EXPERIMENT NO. 27

Position of Blossoms	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	0											
(*b*)	34	23		10	1		2			2		
(*c*)	25	14		10	1		6			6		

As shown in previous experiments, the removal of the petals no longer advertises a cotton blossom to the notice of bees. The same results are obtained when the petals are no longer visible, although still attached to the blossom as at (*a*). It is natural to suppose that the presence of honey would add appreciably to the zone of alluring odors surrounding the blossom.

Without the conspicuous corolla to invite inspection, however, the bees are not led to approach sufficiently near to discover the blossom by its attendant odors alone. These results are not in agreement with some of the general conclusions of Plateau in his noteworthy memoirs: "Comment les fleures attirent les insectes." He states: "Les insectes visitent activement les inflorescences qui n'ont subi aucune mutilation mais dont la forme et les couleurs sont masquées par des feuilles vertes."[3] This would follow only when other attractive influences were actively operative, as various odors agreeable to bee visitors.

Experiment No. 28.—August 1. Time of observation one half hour, from 9:30 to 10:00 A.M. This experiment makes use of most of the material and the same positions of the preceding, with the changes as follows:

[3] *Bulletin de l'Académie royale des Sciences,* No. 11, November, 1895.

(*a*) Outer leaf covering removed from the blossom used at (*a*) in preceding experiment, thus making the outer surface of the petals visible. Honey at the base within, as before.

(*b*) Normal blossom pinned in position as a control. No honey has been added to this blossom.

(*c*) Normal blossom used in preceding experiment with petals removed.

DATA FOR EXPERIMENT NO. 28

Position of Blossoms	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Eltis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Eltis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	9	3		6			0					
(*b*)	11	4		5	1	1	1			1		
(*c*)	1			1			0					

By the removal of the outer covering of the blossoms at (*a*), which in the previous experiment received no inspections, it became nearly or quite as attractive as the control at (*b*). The blossom at (*c*), however, no longer afforded means of attracting the bees. In this experiment and the previous one the corolla at (*a*) was concealed with portions of cotton leaves to guard against introducing repellent odors which may have attended the use of any other material. In the course of this experiment the number of bees flying about became much reduced toward ten o'clock, although the day was clear, hot and sunny. The writer was even forced to postpone his observations for the remainder of the forenoon owing to the scarcity of visiting bees.

Experiment No. 29.—August 1. Period of observation one half hour, from 2:00 to 2:30 P.M. The material is arranged in the same row.

At (*a*) a cotton bud not due to open until the next morning had its petals quite fully pulled open so as to resemble a naturally opening blossom.

At (*b*) a second cotton bud due to open the next morning had its petals partly pulled open.

At (*c*) a normal cotton blossom growing *in situ* as a control.

DATA FOR EXPERIMENT NO. 29

Position of Blossoms	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	15	5		10			0					
(*b*)	2			2			0					
(*c*)	24	4		20			14			14		

In this experiment it was intended to observe the behavior of bees toward immature buds at (*a*) and (*b*) in comparison with fully expanded, mature blossoms. It was assumed that the former, owing to their immaturity, would perhaps prove less attractive to bees through the sense of smell than the fully matured blossoms. Although not definitely proved, it is reasonable to suppose that the processes of active nectar secretion simultaneously attend the unfolding of the petals and the shedding of the pollen. It would then follow that the odor of the unopened buds at (*a*) and (*b*) would prove less alluring than the blossom at (*c*).

The yellow petals of the blossom at (*a*) have served to invite frequent inspection, although at (*b*) this is not as evident. This difference may depend upon the fact that the bud at (*b*) was much less conspicuous, since the petals have been only slightly pulled open. Whatever the true explanation, the mature, fully unfolded blossom which serves as a control at (*c*) has received many more inspections, nearly 60 per cent. of which are actual entrances.

Experiment No. 30.—August 2. Period of observation one hour, from 9:30 to 10:30 A.M. Two blossoms were arranged in the same row in equally conspicuous positions.

At (*a*) a very clean, thin 5×7 glass plate was sup-

ported in front of a fully opened cotton blossom pinned in position. The surrounding cotton leaves were then carefully drawn in closely around the plate so as to overlap the edges and most of the glass surface. In this arrangement, although the blossom was plainly visible through the glass, only a small portion of the glass surface remained in view.

At (*b*) control. A fully opened cotton blossom was pinned in position.

DATA FOR EXPERIMENT NO. 30

Position of Blossoms	Total Inspections	Distribution by Species					Total Entrances	Distribution by Species				
		Melissodes sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees		*Melissodes* sp.	*Elis plumipes*	Honey Bees	Bumble Bees	Unidentified Bees
(*a*)	18	6		3	4	5	0					
(*b*)	37	20	1	7	4	5	9			5	4	

Of those bees which attempted to inspect the blossom at (*a*), eight flew more or less forcibly against the glass, including two small unidentified bees, one *Bombus* sp., two honey bees and three *Melissodes*. One small bee tried persistently several times to fly through the glass toward the blossom just behind it. It is at once obvious that the blossom at (*a*) invited inspection by passing bees solely through the sense of sight.

Experiment No. 31.—August 9. Observations continued one hour, from 9:00 to 10:00 A.M.

Two blossoms were used in the same row as before. A box of thin wood was carefully constructed for this experiment. The dimensions were such that both cover and bottom were made of thin clear glass by using for each a 5×7 glass plate. These plates fitted tightly in lateral grooves. The box was about 4 inches deep, so that the end of a cotton branch together with its leaves and blossoms could be carefully pushed into a natural position within. By sliding the glass cover into place the box became practically air-tight. The blossom was plainly visible to passing bees, although any attractive

odors which it diffused could no longer act as allurements. When placed in position among the cotton limbs the box and glass were almost completely concealed by drawing in and fastening around it a number of the surrounding leaves. This box enclosed the blossom at (*a*).

At (*b*) control. A natural blossom pinned in position. The blossom at (*a*) received only two inspections, both by small, unidentified bees. The blossom at (*b*) received only five inspections, three being by *Melissodes* and two by honey bees. There were no entrances at (*b*).

Experiment No. 32.—August 9. Observations continued for one half hour, from 10 to 10:30 A.M. This experiment was identical with the preceding, except a third artificial blossom was added.

(*a*) Same blossom enclosed in the glass case as used at (*a*) in Experiment 31.

(*b*) The same control blossom pinned in position.

(*c*) An artificial paper blossom of crepe paper simulating a cotton blossom in color.

The blossom at (*a*) received one inspection by a *Melissodes* which hovered in front of the glass a few seconds only.

(*b*) Received eight inspections, which include two entrances by honey bees. The six inspections were entirely by Melissodes. Three bees inspected the artificial paper blossoms at (*c*), including one each by a *Melissodes,* an unidentified bee, and a honey bee, which paused for a few seconds over the blossom but did not enter. During the last few days bee visitors have been rather too infrequent for satisfactory work, probably in part owing to the partly cloudy forenoons.

Experiment No. 33.—August 11. Observations continued for about one half hour, from 9:00 to 9:30 A.M. Three blossoms are arranged in a row.

At (*a*) three petals were placed in position on a leaf which was spread out flat and held between two thin clean 5×7 glass plates bound firmly together. This was placed in position among the branches of a plant and was nearly concealed by overlapping around it a number of cotton

leaves. In this arrangement the yellow petal color still remained perceptible to the visual powers of bees.

At (*b*) the detached petals of a cotton blossom were enclosed in a 250-c.c. graduated flask which was stoppered and fastened among the cotton leaves. The yellow petals were plainly visible through the clear thin glass of the flask.

At (*c*) a normal cotton blossom as a control.

(*a*) Received no inspections.

(*b*) Received one inspection by a honey bee which touched the flask.

(*c*) Received three inspections by honey bees. Two bees did not enter the blossom but alighted outside to get at the extra-involucral nectaries. During this experiment the bees were too infrequent visitors to make any results conclusive.

Experiment No. 34.—August 12. Time of observations 45 minutes, from 1:30 to 2:15 P.M. This experiment was an exact duplicate of the previous one.

(*a*) Petals of cotton blossom on a leaf between glass plates as at (*a*) in Experiment 33.

(*b*) Petals of cotton blossoms enclosed in a flask as at (*b*) in Experiment 33.

(*c*) Normal blossoms growing *in situ* as a control.

The blossom at (*a*) was twice inspected by *Melissodes*. The petals in the flask at (*b*) were inspected two times by bees, once by a honey bee and once by a small, unidentified bee. The blossom at (*c*) was inspected six times, including five entrances. One inspection was made by a small, unidentified bee, four entrances were by honey bees, and one entrance by a *Melissodes*.

For several days it was rather difficult to secure satisfactory data, as the bees were much less frequent visitors. The species of *Melissodes,* which were extremely common at the beginning of the experiments finally became far less common, although honey bees greatly increased. It is very interesting to note that many honey bees finally began to confine their visits solely to the outer involucral nectaries instead of entering the blos-

soms. This change of habit seemed to become quite general at about the same period, for the writer noted it in all parts of the cotton field.

Throughout the period of observations the bees by their behavior and varying numbers showed themselves extremely sensitive to atmospheric changes, temperature relations, air movements, moisture, sunshine, etc. At times conditions even too obscure for human perception may have regulated their activities. The composition of the bee fauna to be observed in cotton fields shows much variation, depending upon the time of day, prevailing weather and seasonal influences. The position and exposure of the cotton field with relation to various local physiographic features, as type of soil, nearness to woods, swamps, hills and other crops also greatly influence the relative numbers and kinds of bees.

While carrying on his observations the writer noted that the bees, *Melissodes,* were exceedingly abundant among cotton grown on certain heavy, red-clay soils. These bees were much less abundant in fields on the lighter, sandy loams in some other localities. Honey bees are especially noticeable near bee trees or domestic hives. The marked abundance of other bees in particular localities likewise probably depends upon the proximity of the plants to their favorite breeding places.

Nectar glands are especially abundant on the cotton plant, including the leaves as well as the blossoms. The blossoms are supplied with several sets of nectaries. Cotton blossoms with their abundant supplies of readily accessible pollen and nectar and their open structure exclude few insect visitors. It follows that a considerable number of species of bees, wasps and other insects are at all times especially common visitors among cotton blossoms.

During the time the experiments previously described were in progress nearly 2,000 bees were observed to perceive, inspect or enter the blossoms and other material involved. 1,645 of these visits were distributed as follows: 1,381 or 83.9 per cent. were by species of *Melis-*

sodes. 130 or 7.8 per cent. were by honey bees. 40 or 2.4 per cent. were by bumble bees. 83 or 5 per cent. were by various unidentified bees.

Eleven visits were made by *Elis plumipes* and one by a large butterfly. The size and yellow color of the petals serve to make cotton blossoms particularly conspicuous in contrast with their shaded background of dark green foliage. Once visiting insects have entered a cotton field, there is little doubt but that their visual powers almost wholly enable them to discover the blossoms. This is indicated by those experiments where the corolla of certain blossoms has been covered or entirely removed, since following this procedure the remaining portions of the blossoms were unvisited. The size and general appearance of cotton blossoms do not appear to be of great importance in initiating the process of inspection, since a single petal may receive as many inspections as the control. It is of interest to note in this connection that in experiments 14 and 15 the bees did not discriminate between the white convolvulus and cotton blossoms at least until after closer inspection. When such artificial material as cloth or paper was used, although the color more or less resembled cotton petals, the bees were rarely induced to inspect it closely. This discrimination may depend upon perceptible differences in color and texture rather than the presence of repellent odors which the material possessed. Many eminent observers have adduced a great deal of evidence which proves beyond doubt that bees develop keen powers of discernment in their associations with the structural details of different flowers.

The actual number of entrances into cotton blossoms is small in comparison with those instances when blossoms have been merely perceived or inspected. The writer's observations show that of 1,061 inspections of the control blossoms only 129, or 12.1 per cent., were actual entrances. One hundred and twenty of these entrances were distributed among the several kinds of bees, as follows: 45, or 37.5 per cent., were by *Melissodes;*

45, or 37.5 per cent., were by honey bees; 6, or 5.0 per cent., were by *Elis plumipes;* 16, or 13.3 per cent., were by bumble bees; 8, or 6.6 per cent., were by various small unidentified bees. A single entrance was made by a large butterfly.

Although it seems clear that the corolla of cotton blossoms invites the first approach of the bees through their visual sense, it is not so easy to determine the relative importance of the sense of sight and smell involved in their nearer inspections. Just why do so few bees decide to enter? In their careful inspection of a single petal or a suspicious blossom is the sense of sight alone involved? Except for a single *Elis plumipes,* no bee has ever alighted upon detached cotton petals, although these have served to attract attention quite as often as the control blossoms. It is not unusual, however, for the bees to inspect these structures very intently, almost touching the surface in their movements over them. The bees have just as persistently refused to enter all artificial blossoms or blossoms mutilated by removing a part or all of the petals. In experiment 6 a bee was completely deceived by the unreal structure at (*c*) made to simulate an expanding bud by the use of actual cotton petals and portions of a cotton leaf. In this instance the bee inspected and finally squeezed itself down between the petals. Unless the fresh petals themselves possess a characteristic odor, odors such as might emanate from a normal blossom were entirely lacking and, therefore, could not have induced the bee to enter. Plateau concludes that visual conspicuousness by means of bright colors is of no advantage whatever to blossoms so far as insect visitors are concerned. He claims that if in nature all blossoms were green like the surrounding foliage, they would be just as readily discovered by bees and other insects in virtue of their odor. The writer's experiments in the field indicate that conspicuousness in virtue of their position and yellow coloration is a very important factor in leading bees and other insects to perceive cotton blossoms.

It does not appear that the addition of small quantities of honey either upon the petals themselves or at the base of the flower within appreciably increased the inspections or entrances, although if a bee chanced to discover this honey, its fondness for it was evinced by its strong reluctance to leave.

It is probable that the inspections are largely of a visual nature, though these may be supplemented by certain odors when the blossoms are more closely examined. Many noted observers, especially Müller, have adduced abundant evidence to prove that the visual power of bees becomes very critical in their behavior toward minute differences of floral structure.

The bee *Melissodes bimaculata,* which is probably by far the commonest of this genus in certain cotton fields at Thompson's Mills, behaves somewhat differently from other bees in its inspections. Its flight is swift and irregular, and its entrance into a blossom is usually preceded by a more careful examination than that resorted to by bumble bees, the common honey bee, or the wasp *Elis plumipes.* It is the usual procedure for the last to fly straight into a blossom or almost drop into it from above, apparently without troubling itself about any preliminary examination. The bumble bees too are less fastidious in their closer inspection.

Many instances are recorded which illustrate the habit of bees to profit by previous successful or unsuccessful experiences. A sort of memory by association is developed so that older, more experienced bees often appear to work among blossoms to much better advantage than younger bees. As an illustration of the influence of previous association upon subsequent behavior, the writer cites the following interesting instance which has come under his observation at Thompson's Mills, North Georgia. It has been mentioned that the common honey bee sooner or later discovers the outer involucral nectaries of cotton blossoms and visits them very constantly, seemingly in preference to the inner floral

nectaries. These particular nectaries, although present in our common American cottons, are never found on the Asiatic cottons, *Hawasaki,* etc. In the writer's variety tests these foreign cottons have been grown side by side and sometimes intermingled in the rows with the American cottons. The honey bees, in passing from blossom to blossom, visiting each time the outer involucral nectaries occasionally met the Asiatic variety. The previous association with the American cottons and their outer involucral nectaries led these bees to visit without success similar structures of the unfamiliar Asiatic variety. The bees quickly recognized their error after alighting and left the blossoms. Is this procedure other than the working of an associative memory? The writer is of the opinion that the honey bees do not discover these extra-floral nectaries until after more or less association with cotton blossoms each summer. This habit of the honey bee appears to become more noticeable later in the season. During the season of 1908 it appeared to be very general. It is a habit which seems to be almost wholly confined to honey bees.

These visits of the bees to the outer basal portion of the Asiatic cotton blossoms indicate that the visual powers alone were employed throughout the process. Although the bees first discovered the blossoms by their conspicuous petals, it is evident that they were led to search for outer involucral nectaries on the Asiatic cotton blossoms solely by their familiarity with the general form and structure of cotton blossoms.

As an illustration of associative memory this behavior of the honey bees is exactly similar to the behavior of certain bees in experiments conducted by Pérez[4], who used scarlet pelargoniums which are not visited by bees, since those flowers possess no nectar. He added honey to certain flowers which were then visited by bees, and says:

[4] Pérez, J., "Notes Zoologiques" (*Actes de la Société Linnéenne de Bordeaux,* Vol. XLVII, série V, tome VII, pp. 250–251, 1894).

La couleur écarlate s'était si bien associée dans leur souvenir à l'idée du miel, qu'elles se passaient à la fin sur des fleurs de cette couleur n'en ayant pas reçu, et ne les quittaient qu' apres s'être assurées, par un examen scrupuleux et persistant, qu'elles n'avaient rien à y recueillir.

A translation of his own words follows: "Scarlet color and honey had become so closely associated in their minds that they finally alighted upon flowers of the same color which had received none, and would not leave until they had assured themselves by a scrupulous and persistent examination that these flowers had nothing to offer them." Plateau gets precisely the same results when he says:

Lorsque l'insecte avait ainsi absorbé le liquide d'un certain nombre defleurs miellees, il lui arrivait de se diriger vers les Pelargoniums non nunis de miel.[5]

"After the insects had gathered honey from a number of flowers to which it had been added, they were then led to visit Pelargonium blossoms which had not received it." These observations are hardly in agreement with the rather radical conclusions of Bethe[6] that bees are devoid of sense impressions, and are incapable of profiting by previous experiences, that their activities are purely reflex, mechanical. Forel, Wasman, Buttel-Reepen, Huber and others have shown, nevertheless, that bees do profit by previous experiences and form habits under certain conditions. Lovell[7] has shown that once bees have been accustomed to visiting a certain color, they tend to return to it regularly until it is to their advantage to change. Once the bees have entered the cotton fields, it is quite obvious that they are led to discover the blossoms by the conspicuous corolla. It would be interesting to learn just how they find the fields themselves. Although a single cotton blossom does not

[5] *Bulletin de l'Academie royale de Belgique*, 3e série, 33, January, 1897.

[6] Bethe Albrecht, "Durfen wir Ameisen und Beinen psychische Qualitäten zuschrieben?" in *Arch. f. d. ges. Physiologie*, Bd. 70, 1898.

[7] Lovell, John H., "The Color Sense of the Honey Bee: Can Bees Distinguish Colors?" AMER. NAT., Vol. XLIV, No. 527, November, 1910.

seem especially odoriferous, it is not improbable that a field of well-developed cotton plants may readily advertise its location to the olfactory sense of bees by odoriferous clouds, so to speak, which are wafted away with every air-movement. During a hot, sunny afternoon the combined odors volatilizing from the great numbers of foliage and floral nectaries, the pollen, etc., must be very considerable. Especially during clear sunny days following periods of cloudy or rainy weather bees become unusually active and numerous. Many of these visitors have no doubt learned the location of the fields by previous association.