A Preliminary Study in the Biometric Variations in the Indian Honey Bee.

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Introduction. The existence of variations in plant or animal life is the factor that facilitates the work of the biologists towards the isolation of the more useful varieties for purposes of further improvement. Newton (1917), Ghosh (1936) and Ramachandran (1937) have recorded about the larger honey storing capacities, their darker colour and larger size of some hill varieties of Indian bees. Even in the varieties found in the plains, the present author has observed certain colonies showing remarkably desirable characters, such as mild temper, minimum swarming propensities, larger honey gathering and stamina to resist unfavourable seasonal conditions. Ramachandran (1937) has also made mention of the different "idiosyncracies" of the various hives in an apiary. A detailed study of the biometric variations, if any, that differentiate bees possessing diverse characters has not so far been made in India.

Review of Literature. Merrill (1922) working in America found that there is a distinct correlation between tongue length of bees and their carrying capacity, that the colonies having bees with longer tongues contain heavier bees and are more populous in spring, and that if a bee is deficient either in tongue length or in weight or in carrying capacity, the disadvantage may be overcome if it possesses the two other of the above three characters to a greater degree. Alpatov (1929) has worked on the biometry of the most important European races of the honey bee based on materials collected in their respective native locations in Europe as well as materials collected in the U. S. A., where the honey bee was imported from Europe. He has classified the influence of different environmental conditions on the honey bee and has concluded that such factors as season, temperature, size of cells, age of combs, nutrition of larva, strength of colony etc.,—all these —affect the biometry of the honey bee. He has also studied in detail the geographical variations in the biometry of the honey bee and finds that the southern constitutional type of the European bee differs from the northern one. This worker further concludes that "parallel to the geographical variation in physical characteristics run the variation of biology and behaviour" such as swarming propensities, preference in collecting nectar from different plants etc. Phillips (1929) has studied the correlations between the various appendages of the honey bee and has concluded that the drones show greater variations than workers and that the size of the comb cell shows great heterogenity and this affects the size of the adult bees. Kellog and Asquith (1934) studied the variations in individual colonies with a view to isolating the more useful ones. They

found certain variations in the capacity of nectar sac and the pollen loads brought by bees but much less variations in biometric measurements. Grout (1937) provided artificial comp foundations with varying cell dimensions and concluded that the size of the brood cell is definitely a factor in determining the size of the adult worker bee. He adds (Grout, 1936) that no increased quantity of honey is proved to have been obtained by the employment of enlarged cell foundations. Nolan (1937) has given a resume of the various attempts made at breeding the honey bee taking advantage of the variations. In some respects the observations of McGregor (1938) are not in conformity with those of Alpatov (1929) since the former has found that nurse bees exert no abnormal influence on the development of worker bees as seen by their tongue and wing dimensions, and that the seasonal trends and honey flow also do not affect tongue and wing lengths.

Material and Methods The present investigation was undertaken to study the biometric variations in the Indian honey bee, collecting material, if possible, from a number of localities, but owing to personal reasons, the author finds it inconvenient to complete fully the scope of the work, and in the present paper, the data so far collected are presented.

The data relate to four colonies of *Apis indica*, which showed some variations particularly in the strength of each colony during a period of a little over three years. Colony Nos. I and IV possessed no supers during all these years, while colony No. II had one super and colony No. III two supers. It was also noticed that colony Nos. II and IV gave almost equal quantities of honey (a three year average of 9·9 lb and 10·2 lb. per annum for colony Nos. II and III respectively) despite the fact that the former has only one super as against two supers possessed by colony No. III.

Alpatov (1929) has concluded that the biometry of the honey bee is affected by a number of environmental factors such as temperature, season etc., and Wedmore (1932) has indicated that even the age of the field bees depends to a very large extent on the amount of work they turn out, and their weight depends on their age. The effect of all these variables has to be reduced to a minimum so as to provide almost identical environmental conditions before comparing the biometry of the bees. And for this purpose, bees were collected from the four hives within a period of six consecutive days.

For his studies in Russia, Alpatov (1929) has used about 100 bees from each colony, and a minimum of five colonies for each locality. But in U. S A. he has taken only five bees from each of ten colonies at each locality for the reason that there is no definite racial variation in U. S. A. where queens only are introduced. It was originally the present author's intention to collect at random 100 bees from each of the four colonies—50 being nectar gatherers and 50 being pollen collectors. But it has only been possible to report on about 50 nectar gatherers taken from each hive.

Bees returning to the hive without any load on their pollen baskets were caught in separate specimen tubes and they were killed immediately in

cyanide bottles used usually in entomological investigations. To find out whether each bee has a load of nectar or water, the bees were placed on a filter paper and their abdomens gently pressed. The contents of the honey sac that is disgorged on the filter paper was allowed to dry for a few seconds. Nectar leaves a translucent spot on the filter paper, but no such spot is left in the case of water. This method of distinguishing nectar-carriers from water-carriers was reported previously by Park (1926) Only nectar gatherers have been used for the following biometric studies, eliminating water carriers.

Measurements of tongue, right forewing, and right hind leg together with the number of hooks on the second right wing were recorded. Wings and legs of the bees were immediately removed and kept mounted on slides. The heads of the bees were macerated in a 5 per cent. solution of potassium hydroxide as described by Alpatov (1929). The tongues were then dissected and kept mounted in glycerine jelly.

Diameter of comb cells. — During the course of study it was casually observed that even the cell measurements in the brood combs of the Indian bee appear to vary. Seven brood combs from one hive (Newton's pattern) were at one time available and leaving aside the few rows of cells at the top which are usually used for storing honey, measurements of the diameter of the worker brood cells that were recorded are furnished in Table I.

TABLE I. Diameter of cells in brood combs.

Unit of measurement	Diameter per cell.	No. of cells.	Percentage of total.
	mm.		
8 cells in 31 mm.	3 7/8	352	2·0
7 ,, 27 mm.	3 6/7	308	1·7
6 ,, 24 mm.	4	4,410	25·0
8 ,, 23 mm.	4 1/8	2,136	12·1
7 ,, 29 mm.	4 1/7	2,156	12·2
6 ,, 25 mm.	4 1/6	2,700	15·3
5 ,, 21 mm.	4 1/5	1,770	10·0
4 ,, 17 mm.	4 1/4	176	1·0
7 ,, 30 mm.	4 2/7	2,163	12·3
3 ,, 13 mm.	4 1/3	897	5·0
8 ,, 35 mm.	4 3/8	360	2·0
5 ,, 22 mm.	4 2/5	225	1·3
		17,653	100·0

It is observed that the frequency distribution of the diameter of the comb cells is multimodal. Philips (1929) and Grout (1937) have stated that this variation in the size of comb cells would affect the development of bees

Tongue— The tongue was measured in three parts, viz, submentum, mentum and ligula. For considerations of space, freguency distribution of the lengths of each of these parts has not been furnished. However, in Table II the mean lengths of these parts in the case of the hives under study are presented.

TABLE II. Length of tongue parts (in millimeters)

Hive Nos.	Submentum.	Mentum.	Total of submentum and mentum.	Ligula.
I	0·293	1·248	1·541	2·891
II	0·295	1·265	1·560	2·900
III	0·278	1·278	1·556	2·821
IV	0·269	1·290	1·559	2·753
Mean of all hives.	0·284	1·270	1·554	2·841

Table II indicates that the longest submentum occurs in hive Nos. 1 and II, and the shortest in hive IV ; but the longest mentum is only in hive IV. It therefore appears reasonable to conclude that the bees from those hives having short mentum have relatively long submentum and *vice versa*. Nevertheless, the total aggregate length of the submentum and mentum display less variations and it is observed that no significant differences in the means of hives II, III, and IV exist As for ligula, hive IV has the shortest while hive II has the longest.

In Table III the frequency distribution of the total length of the proboscis is given. These frequencies show multimodel trends. Hive II appears to possess the longest tongue (about 4·5 mm.) and hive IV the shortest (about 4·3 mm) the mean of all the hives being about 4·4 mm. The frequency trends being multimodal, the general means are not compared.

TABLE III. Total length of proboscis (in millimeters).

Hive No.	3·50 to 3·59	3·60 to 3·69	3·70 to 3·79	3·80 to 3·89	3·90 to 3·99	4·00 to 4·09	4·10 to 4·19	4·20 to 4·29	4·30 to 4·39	4·40 to 4·49	4·50 to 4·59	4·60 to 4·69	4·70 to 4·79	4·80 to 4·89	4·90 to 4·99	5·00 to 5·09	Total.	Mean.
I	...	1	1	1	1	4	5	2	2	5	11	12	1	1	2	1	50	4·435
II	...	...	1	...	6	2	1	1	4	7	4	12	9	2	...	...	49	4·463
III	1	1	2	3	2	...	1	2	9	5	10	10	4	...	...	...	50	4·379
IV	...	1	4	4	2	2	2	5	7	3	8	7	4	...	...	...	49	4·308
Total	1	3	8	8	11	8	9	10	22	20	33	41	18	3	2	1	198	4·397

Right Forewing. In Tables IV and V the length and breadth respectively of the right forewing have been furnished. There was a small accident and some of the slides were destroyed particularly of those from hive III. The length of the wing was measured in two stages, viz. proximal length and distal length, as described by Nolan (1937). The proximal length and distal length are almost equal being about 3·7 mm. From tables IV and V it will be seen that the length of wing of the Indian bee is about 7·4 mm. while its breadth is about 2·6 mm. and no significant differences in the means have been observed. According to Kellog and Asquith (1934) the average wing length of the European bee is about 9·3 mm. while the breadth is about 3·3 mm.

TABLE IV. Length of forewing (in millimeters)

Hive No.	6·91 to 7·00	7·01 to 7·10	7·11 to 7·20	7·21 to 7·30	7·31 to 7·40	7·41 to 7·50	7·51 to 7·60	7·61 to 7·70	7·71 to 7·80	Total.	Mean.	S. D.	S. E.	C. V.
I	...	...	4	6	12	10	6	2	3	43	7·415	0·1536	0·0234	2·1
II	...	1	4	11	8	9	7	3	2	45	7·395	0·1594	0·0238	2·2
III	1	2	1	8	6	7	7	2	...	34	7·376	0·1622	0·0278	2·2
IV	...	2	3	9	17	8	2	...	1	45	7·357	0·1301	0·0194	1·8
Total	1	5	12	34	43	34	25	7	6	167	7·386	0·15 8	0·0117	20

Conclusions :—I. II, III, IV.

TABLE V. Breadth of forewing (in millimeters).

Hive No.	2·41 to 2·45	2·46 to 2·50	2·51 to 2·55	2·56 to 2·60	2·61 to 2·65	2·66 to 2·70	2·71 to 2·75	2·76 to 2·80	Total.	Mean.	S. D.	S. E.	C. V.
I	1	3	4	11	9	9	5	1	43	2·618	0·0753	0·0115	2·9
II	...	1	3	12	14	9	6	..	45	2·630	0·0580	0·0086	2·2
III	...	...	1	8	10	7	8	...	34	2·649	0·0557	0·0096	2·1
IV	...	...	1	10	14	11	8	1	45	2·678	0·0547	0·0082	2·0
Total	1	4	9	41	47	36	27	2	167	2·639	0·0629	0·0049	2·4

Conclusions :—IV, III, II, I.

Nolan (1937) has referred to the ratio between the length of veins marked by him as ***e*** and ***f*** in the third cubital cell of the right forewing, and states that this index is a hereditary factor wherein low cubital index is completely dominant over the high index In table VI this index in respect of the colonies under study is furnished. It will be seen that hive III has a very high index while hive II has the lowest. Although hives I and IV have equal indices the latter exhibits a coefficient of variation of 17·8 per cent as against 12 8 per cent for hive I.

TABLE VI. Third cubital index of right forewing (Ratios)

Hive No.	0·21 to 0·22	0·23 to 0·24	0·25 to 0·26	0·27 to 0·28	0·29 to 0·30	0·31 to 0·32	0·33 to 0·34	0·35 to 0·36	0·37 to 0·38	0·39 to 0·40	0·41 to 0·42	Total.	Mean.	S D	S E.	C. V.
I	...	3	2	4	9	9	7	2	5	2	...	43	0·31	0·0395	0·0060	12 75
II	2	3	5	10	15	8	1	1	...	...	...	45	0·28	0 0279	0·0042	9 96
III	...	...	1	...	2	8	10	3	5	3	2	34	0 34	0·0342	0·0059	10·05
IV	...	4	10	2	9	5	3	2	2	2	6	45	0·31	0·0551	0·0082	17 76
Total	2	10	18	16	35	30	21	8	12	7	8	167	0·31	0·0454	0 0035	14·64

Conclusions :—III, I IV, II.

No. of Hooks on the Second Wing. In Table VII the number of hooks found on the second wing of the bees is indicated. All except colony III have an average of about 17 hooks while colony III alone has 18. This difference is statistically significant.

TABLE VII. Number of Hooks on the Second Wing.

Hive No.	14	15	16	17	18	19	20	21	Total	Mean	S. D.	S. E.	C. V.
I	...	2	9	6	14	2	3	...	36	17·4	1·242	0·207	7·14
II	...	1	11	12	8	5	...	1	38	17·2	1 872	0·223	7·98
III	...	...	1	7	9	8	3	...	28	18·2	0·993	0·188	5·46
IV	1	2	7	15	15	2	2	...	44	17·3	1·060	0·160	6·13
Total	1	5	28	40	46	17	8	1	146	17·5	1·198	0·099	6·84

Conclusions :— III, I, IV, II.

Hind Leg. Separate measurements of femur, tibia and metatarsus were determined but they are not furnished in this paper. But in Table VIII the mean measurements of these parts for each hive is separately given.

TABLE VIII. Measurements of leg parts (in millimeters)

Hive Nos.	Femur.	Tibia.	Metatarsus.	Breadth of Metatarsus.
I	2·09	2·43	1·57	0·94
II	2·09	2·44	1·58	0 94
III	2·08	2·52	1·63	0·97
IV	2·10	2·41	1·55	0·94
Total	2·09	2·45	1·58	0·94

Table VIII indicates that though the length of femur of the bees in hive III is slightly less than that in hives I and II, yet the bees of hive III have relatively longer tibia and metatarsus, and as a result they possess very long legs, and also broad metatarsus. Table IX will show that hives I and II possess bees of equal leg lengths while hive IV has very short legged bees.

TABLE IX. Length of hind leg in millimeters.

Hive No.	5·71 to 5·80	5·81 to 5·90	5·91 to 6·00	6·01 to 6·10	6·11 to 6·20	6·21 to 6·30	6·31 to 6·40	6·41 to 6·50	Total.	Mean.	S. D.	S. E.	C. V.
I	2	3	9	13	10	4	3	1	45	6·08	0·1588	0·0237	2·61
II	...	6	6	10	5	13	3	...	43	6 11	0·1475	0·0225	2·41
III	...	...	4	2	8	16	8	3	41	6·21	0·1356	0·0212	2·18
IV	...	1	11	16	14	6	1	...	49	6·04	0·1009	0·0144	1·67
Total	2	10	30	41	37	39	15	4	178	6·12	0·1397	0·0105	2·28

Conclusions :—III, II, I, IV.

Discussion. The present study was undertaken primarily with a view to find out whether differences in biometry are met with in Indian bees. It has been noticed that wing measurements are almost equal in all the hives.

Hive II, the one super colony, has bees with long tongues, low cubital index, fewer hooks on the second wing, and hind leg of medium length. Hive III which is a very strong colony with two supers has bees with short tongue, high cubital index, larger number of hooks, on the second wing and very long legs. It should be remembered that both hives are almost equal in honey gathering capacities, despite the larger population of bees in hive III.

At best the present study is only of a very preliminary nature and further work on a number of hives of known behaviour would be very necessary before any definite attempt is made at correlating behaviour of bees and their biometry.

Selection and hybridization are the two important lines of work connected with the improvement of any species, and before any attempt at improving the Indian honey bee is taken on hand, a fuller knowledge of the variations that exist in the biometry and behaviour of different colonies of bees, and the correlations if any that exist between them is urgently called for. The consciousness of our farmers to the possibilities of bee-keeping as a cottage industry is now developing very fast, and many of the Provincial and State Governments in India are actively sponsoring schemes for popularising this industry. At this stage it seems very opportune indeed to consider the feasibilitiy of carrying out a more thorough investigation into the biometric variations of bees from various colonies of known behaviour situated in diverse localities. Such a study would perhaps facilitate the compilation of a key for the ready identification of bees possessing desirable characters instead of watching their performances and behaviour over a long period of time. These colonies can be multiplied with advantage and they may form the parent stock for further breeding. Whether particular biometric characters are stable even under changing environmental conditions is also a matter to be thoroughly studied if improving the honey bee by selection is to be successful at all. Queen rearing as an aid to the improvement of honey bee by selection is well recognised in all the important honey producing countries of the west. But so far as the conditions obtaining in India at present are concerned, this method of improving the Indian honey bee seems to be of little importance unless the mating of queens with drones from undesirable colonies can, to a reasonable extent, be prevented.

Summary and Conclusions.— For the first time a study in the biometric variations of the Indian honey bee is reported in the present paper. Four colonies of *Apis indica* have been chosen for study and the tongue lengths of bees, their wing measurements, number of hooks on the second wing, and the length of the hind leg have been recorded. They exhibit some variations in biometry particularly in tongue length, index of the third cubital cell of the right forewing, number of hooks on the second wing, and leg measurements. There is practically no variation in the length and breadth of the right forewing. Some variation in the diameter of comb cells of a hive are also observed.

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A Note on Sugarcane Cultivation in the South Canara District.

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Introduction. There is an area of about 5000 acres under the sugarcane crop in the four coastal taluks of Coondapoor, Udipi, Mangalore and Kasargod in the South Canara District. This area was under one or two local varieties called "Dasa Kabbu" and Bidru "Kabbu". Red mauritius was introduced two decades ago, and now this variety has almost replaced the old local varieties.

The trial of some of the Co-varieties is in progress in the Kallianpur sugar factory area. The performances of a few of the thick cane varieties like Co. 419, 413, 421 and 408 are really good and there is already an area of about 150 acres under these Co-varieties in the two Taluks of Mangalore and Udipi. The results so far achieved go to show that these improved Co-varieties are much superior to the Red mauritius variety, both in tonnage and juice quality, and we hope that within the course of another 10 years, these Co-varieties will completely replace the Red mauritius variety which is fast deteriorating.