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Selection of best performing *Apis cerana indica* Fab. colonies for stock improvement based on comparison of economic characters

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ABSTRACT: The comparative performance on economic characters of Indian bee *Apis cerana indica* Fab. collected from 18 locations of different beekeeping pockets in Kerala were studied during 2012-2013 to find out better performing colonies for selective breeding. The bee colonies collected from highland location Rajakkat (L3) and Rosemala (L6) were black morph and midland location Pathanapuram (L11) and lowland location Kadakkal (L18) were yellow morph and bees from other locations were common brown bees. The black and yellow morphs of *A. cerana indica* are being reported from Kerala for the first time. The black and yellow bee colonies recorded significantly higher mean bee strength, brood area, pollen storage area, honey storage area and honey yield compared to common brown bees. Both black and yellow bee morphs had more tolerance/ immunity against diseases compared to common bees. Absconding behavior was more in black bees while it was not recorded in yellow bees. These black and yellow bee colonies can be utilized for stock improvement through selective breeding for enhanced honey production.

KEY WORDS: *Apis cerana indica*, black morph, yellow morph, comparative performance, brood area, pollen storage area, honey yield

INTRODUCTION

The honey bee, *Apis cerana indica* is the predominant bee species widely used for commercial beekeeping in Kerala. Even though the industry had progressed recently, honey production is not upto the desired level due to lack of colonies /strains with desirable traits. Verma (1994)

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pointed out that a solution for low honey production, diseases, swarming and absconding characters of the species has to be worked out for sustainable apiculture with Indian bee. According to Chhuneja (2006 a,b), the only method for achieving the target will be stock improvement of the Indian bee *A. c. indica* by identifying the best genetic material from already available stocks, segregate promising colonies/queen bees on the basis of important economic and behavioural parameters and subsequently adopting inter-breeding through different mating combinations, avoiding any inbreeding.

Although beekeeping is a common practice in Kerala, studies on honey bee productivity or stock improvement of *A. cerana indica* is lacking. Hence an attempt was made to identify Indian bee colonies with better viable characters from among the existing bee colonies in Kerala.

MATERIALS AND METHODS

Eighteen locations from three natural topographic divisions of Kerala *viz.*, Highland (750 – 1700 m above MSL), Midland (100-750 m above MSL) and Lowland (25 – 100 m above MSL) (Table 1) were selected for the present study.

A. cerana indica colonies were selected from the apiaries of bee breeders / progressive beekeepers in locations mentioned in Table 1. Selection of colonies was done by checking colony registers maintained by the beekeepers with data on the performance and honey yield of the colonies in the previous years and also by visual observation of the colonies. Colonies with newly mated queen, six combs and approximately same bee strength (three frames) were selected. Three such colonies were collected from each location, marked and were brought to an apiary at Kadakkal, Kollam district. The colonies were kept strong and healthy, under same condition, by adopting the management practices recommended by the Kerala Agricultural University POP (Package of Practices).

Comparative performances on the economic characters (bee strength, brood area, pollen storage area, honey storage area and honey yield) were recorded from August 2012 to July 2013. Observations were recorded at 15 day intervals. Bee strength was assessed by counting comb well covered with bees on the two sides as one (Taha, 2007). The brood area, pollen storage area and honey storage area were recorded using a grid, which consist of a number of squares each measuring one square centimeter in area. The cells with brood / pollen/honey scattered in a comb was counted separately and converted into square cetimeters (Verma, 1998). Honey from the super chambers was extracted at intervals of eight days and weighed. Disease incidence was recorded through visual observation at fortnightly intervals. Number of colonies absconded were recorded at 15 day intervals. The data obtained were subjected to analysis of variance.

Table 1. Locations selected for collection of *Apis cerana indica* colonies

Topographical division	Agroclimatic zone	Location code	Location (District)	Altitude M) Above MSL	Longitude (°E)	Latitude (° N)
	Northern	L1	Sulthan Bethery (Wayanad)	1000	76°.2990	11°.72127
		L2	Panathady (Kasaragod)	750	75°.1302	12°.21327
Highland	Central	L3	Rajakat (Idukki)	1700	77°.0667	10°.1213
		L4	Adimali (Idukki)	1100	76°.9561	10°.0148
	Southern	L5	Amboori (Trivandum)	980	77°.8223	8°. 5025
		L6	Rosemala (Kollam)	1100	77°.1431	8°.9667
	Northern	L7	Peravoor (Kannur)	125	78.8256	9°.6729
		L8	Thamarassery (Kozhikode)	722	75°.3411	11°. 4912
Midland	Central	L9	Palakkad (Palakkad)	467	76°.3911	10°. 4625
		L10	Mundakayam (Kottayam)	330	76°.8833	9°.5500
	Southern	L11	Pathanapuram (Kollam)	120	76°.8882	9°.10 86
		L12	Nedumangadu (Trivandrum)	223	77°.0012	8°. 35 60
	Northern	L13	Ulikkal (Kannur)	25	75°.3900	12°.2031
		L14	Parappa (Kasaragod)	38	75°.2254	12°.3617
Lowland	Central	L15	Cheruthuruthi (Thrissur)	49	76°.2733	10°.7433
		L16	Perumbavoor (Ernakulam)	33	76°.4784	10°.1211
	Southern	L17	Neyyattinkara (Trivandrum)	75	77°.0833	8°.4240
		L18	Kadakkal (Kollam)	75	76°.9137	8°.8316

RESULTS

Comparative performance of *A. cerana indica* colonies from different locations

Two distinct colour morphs of *A. cerana indica* could be observed from certain beekeeping pockets in the present study, in addition to the common brown bees, Bees from L3 and L6 were black morphs, those from L11 and L18 were yellow morphs and bees from other locations were common brown bees. The colour of the queen and workers was differing compared to common brown bees. In black bees the abdomen of the queen was very black and that of yellow bees was yellowish brown and in common brown bees it was dark brown. The colour of the abdomen of worker bees were also very distinctive (Fig. 1,2,3).

a. Bee strength (No. of bee frames)

Data on bee strength of colonies from different locations are shown in Table 2. Mean bee

Table 2. Monthly variation in bee strength (No. of frames with bees on both sides) of *Apis cerana indica* colonies from different locations during 2012-13

Locations	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Pooled mean
L1	3.001	3.208	3.750	3.937	2.574	2.966	3.276	3.625	3.014	2.479	2.995	3.282	3.175
L2	3.155	3.250	4.500	5.841	3.791	4.608	5.227	5.052	4.255	3.887	4.451	5.034	4.421
L3	3.145	3.335	5.083	6.537	5.175	7.012	7.452	7.123	6.104	4.708	6.073	7.010	5.729
L4	3.130	3.166	3.916	5.379	3.495	4.449	4.885	4.010	3.645	3.470	4.383	4.911	4.069
L5	3.112	3.125	4.665	5.441	3.317	3.795	4.289	4.125	4.525	3.455	3.766	4.087	3.975
L6	3.150	3.375	5.249	6.525	3.474	4.912	5.624	5.220	4.350	5.782	6.011	6.622	5.025
L7	3.160	3.165	4.145	5.212	3.533	4.575	5.232	5.120	4.120	3.786	4.241	4.848	4.261
L8	3.255	3.541	3.958	4.204	2.646	3.195	3.625	3.401	3.247	2.680	2.953	3.353	3.338
L9	3.300	3.665	5.335	5.829	3.750	4.587	5.312	5.184	4.100	3.987	4.407	5.046	4.541
L10	3.205	3.335	4.224	4.424	2.533	3.416	3.872	3.630	3.533	2.765	3.120	3.556	3.467
L11	3.148	3.333	5.624	6.496	4.112	5.837	6.568	6.272	5.540	4.570	5.252	6.115	5.238
L12	3.205	3.291	4.200	4.025	2.391	3.020	3.414	3.648	3.224	2.640	2.851	3.115	3.252
L13	3.150	3.233	4.666	5.654	3.258	4.541	5.078	5.011	4.333	4.065	4.504	4.753	4.353
L14	3.175	3.183	4.835	5.516	3.766	4.837	5.405	5.200	5.000	4.250	4.620	4.999	4.566
L15	3.125	3.191	4.808	5.466	3.608	4.208	4.778	4.555	4.125	3.906	4.499	4.831	4.258
L16	3.175	3.275	4.635	5.570	3.687	4.624	5.067	5.012	4.720	3.945	4.163	4.411	4.357
L17	3.120	3.250	4.274	5.200	3.529	3.741	3.829	3.432	3.135	2.822	3.027	3.193	3.546
L18	3.165	3.358	5.333	6.133	4.308	5.658	6.911	6.244	5.344	4.780	5.339	5.996	5.214
CD	*NS*	*NS*	*0.5174*	*1.0948*	*1.657*	*2.551*	*2.8743*	*2.9641*	*2.5743*	*2.1045*	*2.5725*	*2.7324*	

Fig.1 Black morph of *Apis cerana indica*

Fig. 2 Yellow morph of *Apis cerana indica*

Fig.3 Common brown morph of *Apis cerana indica*

strength in colonies from all the locations was same during August and September. Highest mean bee strength (5.624) was observed in colonies from L11 followed by L9 (5.335) and L18 (5.333) during October which was on par with that of black bees from L6 (5.249) and L3 (5.083). Bees from L1 showed the least mean bee strength (3.750). There was a gradual increase in bee strength in September and reach a high level in November. Black bee colonies from L3 and L6 had mean bee strength of 6.537 and 6.525 respectively during November which were on par with those of yellow bee colonies from L11 and L18 (6.496 and 6.133 respectively) compared to common brown bees from other locations. During the month of December highest mean strength was observed in black bees from L3 (5.175) which was significantly higher than that of bee colonies from other locations.

Bee strength was highest (7.021) in black bee colonies from L3 followed by L11 (5.837) and L18 (5.658) during January and least was in brown bees from L1 (2.966).The second peak in bee strength was observed during February. Mean bee strength was highest in black bee colonies from L3 and L6 (7.452 and 5.624 respectively) and in yellow bees from L18 and L11 (6.911 and 6.568 respectively) which were on par and significantly higher than brown bees. Same trend was observed during March also. The black bees (L3, L6) and yellow bees (L11, L18) recorded highest mean bee strength (7.123, 5.220, 6.272, 6.244 respectively) which were on par with that of L2, L6,L7, L9, L13,L14,L15,L16. During April mean bee strength declined in all the colonies and black bees from L3 recorded the highest (6.104) which was on par with that of yellow bees from L11 and L18 (5.540 and 5.344 respectively). Bees from all other locations recorded significantly lower bee strength.

The mean strength decreased again during May and highest bee strength (5.782) was

observed in black bee colonies from L6 which was on par with that of yellow bees from L11 and black bees from L3, L6. During June also the black bees from L3 and L6 showed highest bee strength (6.073 and 6.011) which was on par with that of yellow bees from L18 and L11 (5.339, 5.252 respectively). Same trend was noticed during July also with highest bee strength of 7.010 in L3 followed by L6. Least mean bee strength was observed in common brown bees from L12.

b. Brood area (cm^2)

The black bees from L3 had the highest mean brood area (553.167 cm^2) during September (Table 3) which was significantly higher than other colonies and it was followed by black bees from L6 (438.833 cm^2), yellow bees from L18 (438.165 cm^2) and L11 (429.833 cm^2). The lowest brood area was recorded in common brown bees from L1 (233.335 cm^2). During October, highest mean brood area was recorded in black bees from L3 (912.665 cm^2) which was on par with that of black bees from L6 (830.165 cm^2) which were statistically higher to other locations. Mean brood area in yellow bee colonies from L18 (729.500 cm^2) and L11 (726.167 cm^2) were on par. Least brood development was observed in colonies from L1 (395.166 cm^2). The black bees from L3 recorded the highest mean brood area (1260.084 cm^2) during November which was on par with that of black bees from L6 (1165.000 cm^2). Mean brood area in yellow bee colonies from L11 (1035.751 $cm^{2)}$ was on par with that of bees from L6. Common bees from L12 showed the lowest brood area (562.000 cm^2) during this period. During December, maximum mean brood area of 879.417 cm^2 was recorded in black bee colonies from L3 which was on par with that of yellow bees from L18 (704.666 cm^2) and were statistically higher to bees of other locations. It was followed by the yellow bees from location 11 (630.085 cm^2), common bees from L4 (559.083 cm^2) and black bees from location 6 (539.250 cm^2). The common bees from location 10 showed the least brood development (281.750 cm^2).

Maximum mean brood area was recorded in black bee colonies from L3 during January (1438.417 cm^2) which was statistically significant from bees of other locations. It was followed by the yellow bees from L18 and 11which were on par (979.917 cm^2 and 841.667 cm^2 respectively). Least mean brood area of 335.250 cm^2 was recorded in common bees from L8. During February, also the black bees from L3 recorded highest mean brood area (1666.667 cm^2) which was on par with that of yellow bees from L18 (1240.250 cm^2) followed by bees from L11 and L6 which were also on par (1189.309 cm^2, 1134.122 cm^2). Lowest brood area was recorded in bees from location 8 (396.634 cm^2). All the colonies from other locations recorded comparatively less brood area. Highest mean brood area (1587.145 cm^2) was recorded in black bees from L3 during March which was significantly higher. Yellow bees from L18 recorded a mean brood area of 1186.867 cm^2 followed by bees from L11 and L6 (1098.167 cm^2, 1021.312 cm^2) which were on par. Lowest brood area was recorded in bees from L8 (322.013 cm^2).

During April mean brood area declined in all the colonies and black bees from L3 recorded the highest brood area (1066.145 cm^2) which was on par with that of yellow bees from L6, L18 and L11 (998.634 cm^2, 986.938 cm^2, 877.966 cm^2 respectively). The least mean brood area (288.516

Table 3. Monthly variation in brood area (cm^2) of *Apis cerana indica* colonies from different locations during 2012-13

Locations	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Pooled mean
L1	230.115	233.335	395.166	586.083	381.667	493.335	547.195	568. 925	465.122	174.416	200.583	233.083	268.301
L2	268.227	286.667	573.000	713.167	435.583	596.165	675.110	684.251	597.321	302.083	367.916	429.166	424.121
L3	420.250	553.167	912.665	1260.084	879.417	1438.417	1666.667	1587.145	1066.145	693.250	1079.833	1540.750	1094.995
L4	330.557	332.667	516.000	778.000	559.083	676.250	751.312	751.312	452.815	255.916	328.665	393.750	357.786
L5	250.350	253.666	447.667	661.500	470.585	617.333	685.146	668.016	569.417	246.750	278.916	320.583	353.917
L6	345.750	438.833	830.165	1165.000	539.250	742.333	1134.122	1021.312	998.634	527.500	688.749	990.665	801.387
L7	350.125	354.335	601.333	756.835	417.916	496.250	552.101	517.314	418.745	292.335	343.416	373.416	356.978
L8	285.265	343.165	548.835	593.583	291.750	335.250	396.634	322.013	288.516	227.666	222.916	294.083	258.295
L9	380.550	418.000	703.335	827.667	495.667	593.417	675.588	627.158	562.054	335.916	381.500	460.249	434.929
L10	290.785	301.835	508.833	614.000	281.750	367.917	443.772	439.243	333.748	187.582	225.250	262.250	252.207
L11	385.780	429.833	726.167	1035.751	630.085	841.667	1189.309	1098.167	877.966	492.165	789.166	1039.917	799.804
L12	325.256	349.665	557.833	562.000	310.083	382.318	552.787	500.378	387.004	218.995	292.833	356.833	313.916
L13	310.066	348.166	612.830	742.915	466.417	612.835	687.691	622.914	426.545	395.833	445.335	499.416	441.782
L14	365.250	413.500	735.000	825.833	424.250	542.833	659.500	609.275	507.151	368.083	417.833	499.000	448.017
L15	293.355	374.500	588.466	738.917	447.500	454.665	585.111	564.852	498.822	343.666	411.833	490.835	436.289
L16	247.900	348.500	594.500	716.416	388.833	481.000	548.387	519.768	408.111	270.500	309.500	375.166	340.819
L17	374.252	405.333	556.665	701.165	391.583	458.333	532.833	499.637	349.266	235.995	292.000	363.500	310.19
L18	395.275	438.165	729.500	967.832	704.666	979.917	1240.250	1186.867	986.938	719.083	924.085	1105.167	933.818
CD	87.37	94.29	132.681	180.256	227.114	335.183	417.776	301.825	283.365	183.2466	221.6074	264.4436	

cm^2) was recorded in bees from L8. Brood area decreased again during May and highest brood area (719.083 cm^2) was observed in yellow bee colonies from L18 which was on par with that of black bees from L3 (693.250 cm^2) and L6 (527.500 $cm^{2)}$. Common bees from L1 recorded the least brood area (174.416 cm^2). During June, black bees from L3 (1079.833 cm^2) and yellow bees from L18 (924.085 cm^2) recorded highest brood area which were on par. Same trend was noticed during July also with a highest mean brood area of 1540.750 cm^2 in L3 followed by L18 (1105.167 cm^2) followed by L11 (1039.917 cm^2). Least mean brood area (233.083 cm^2) was observed in common brown bees from L1.

c. Pollen storage area (cm^2)

Pollen storage area in different colonies did not show significant variation from August to November and March to July (Table 4). During December, the yellow bees from L11 and L18 showed highest mean pollen storage area (107.749 cm^2 , 103.167 cm^2 respectively) which was on par with those of bees from L16, L13, L14, L17 and the colonies from L8 showed the lowest pollen collection (49.333 cm^2). During January, yellow bees from L11 and L18 had highest mean pollen area (166.000 cm^2, 164.916 cm^2) which was on par with L16, L13, L14 and L15.and bees from L1 showed the least pollen collection (53.749 cm^2). During the month of February the brown bees from L15 showed high mean pollen storage area (114.185 cm^2) which was on par with that of L14, L16, L13, L9, L6 and L18 and the colonies from L7 recorded least pollen storage area (38.873 cm^2).

d. Honey storage area (cm^2)

The results obtained on the honey storage area are presented in Table 5. Mean honey storage area was highest in colonies from L18 and L10 (283.166 cm^2 and 265.500 cm^2 respectively) during September which were on par with that of L13, L11, L9, L6 and L8. All other colonies showed less honey storage area and the bees from L4 recorded the least (115.667 cm^2). Honey storage in yellow bee colonies from L11, black bee colonies from L6, yellow colonies from L18 and brown bees from L8 (377.165 cm^2, 366.165 cm^2, 361.665 cm^2, 361.333 cm^2 respectively) were on par during October followed by bees from location 10, 13, 9, 3,5. The least honey storage (197.333 cm^2) was observed from bee colonies of L16. Highest mean area of honey storage (349.333 cm^2) was recorded in yellow bees from L18 during November, which was on par with that of L6, L11, L3, L9, L4 and L13. Least honey storage was observed in colonies from location 12 (125.333 cm^2) which was significantly low from all other bee colonies. No significant difference observed in honey storage area during December. The highest mean honey storage (326.417 cm^2) was observed in yellow bee colonies from L18 followed by the black bees from L3 (320.583 cm^2). Least mean storage of 133.167 cm^2 was observed in colonies from L12.

There was a gradual increase in honey storage area and it was highest during January to May and then there was a gradual decrease and least mean honey storage was observed during July. Black bees from L3 and L6 had a mean honey area of 446.330 cm^2 and 377.750 cm^2 during January which were on par with that of the yellow bees from location 11 and 18 (416.085 and

Table 4. Monthly variation in pollen storage area (cm^2) of *Apis cerana indica* colonies from different locations during 2012-13

Locations	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Pooled mean
L1	28.148	18.998	22.333	47.617	47.750	53.749	41.612	24.152	21.053	44.249	41.5	33.415	35.381
L2	16.255	47.666	63.667	65.666	78.833	85.750	75.593	62.025	51.422	78.416	82.75	88.583	66.385
L3	85.339	108.833	131.000	77.333	70.833	100.333	70.207	24.158	18.357	67.245	95.917	98.750	79.025
L4	45.174	43.498	44.000	46.916	56.666	75.499	67.083	35.147	28.264	64.665	13.165	20.833	45.075
L5	22.782	52.833	62.833	54.666	57.250	70.332	46.895	36.295	12.379	59.334	62.995	74.000	51.049
L6	55.378	86.000	99.998	62.166	63.583	94.416	92.002	24.337	16.758	53.000	63.245	69.167	65.004
L7	20.991	29.331	42.500	47.667	57.250	57.774	38.873	32.004	41.285	73.917	65.335	59.416	47.195
L8	64.577	62.666	76.000	49.917	40.666	56.916	62.964	48.177	47.276	38.833	35.495	4.584	49.005
L9	32.186	43.666	79.833	64.667	75.915	100.083	99.793	66.117	69.445	44.417	72.335	105.415	71.156
L10	10.228	17.665	16.500	40.500	49.333	68.166	57.573	40.102	31.225	40.667	65.167	85.083	43.517
L11	33.250	39.500	71.333	94.333	107.749	166.000	75.639	31.355	28.007	62.495	105.667	138.083	79.450
L12	12.455	43.500	69.333	44.083	50.916	81.832	45.087	42.147	48.587	26.083	29.165	32.835	43.835
L13	43.202	38.166	42.000	51.916	90.083	132.166	101.754	96.519	96.519	60.083	73.583	102.083	77.339
L14	47.154	60.833	89.667	82.333	89.833	127.083	110.544	85.334	85.334	54.082	61.916	81.082	81.266
L15	39.460	66.500	63.166	46.416	77.416	123.999	114.185	55.284	55.284	60.500	78.665	94.166	72.920
L16	78.266	80.166	74.667	65.667	94.916	134.416	109.232	94.799	94.799	66.749	52.416	81.749	85.653
L17	37.118	31.665	41.500	62.166	80.583	99.334	98.441	67.125	102.125	79.583	83.750	90.583	72.831
L18	80.566	74.000	94.833	98.333	103.167	164.916	84.500	42.366	194.5	53.917	91.915	117.750	100.063
CD	NS	NS	NS	NS	37.3301	44.9681	66.7608	NS	NS	NS	NS	NS	

Table 5.Monthly variation in honey storage area (cm^2) of *Apis cerana indica* colonies from different locations during 2012-13

Locations	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Pooled mean
L1	125.235	164.333	214.665	208.333	143.499	174.833	174.960	181.152	203.551	226.583	150.333	112.000	160.037
L2	148.330	155.835	226.500	233.915	224.500	270.083	301.224	328.344	364.277	282.766	254.417	174.335	228.194
L3	156.245	163.167	279.666	300.417	320.583	446.330	486.706	488.666	489.150	540.083	431.250	351.582	342.834
L4	97.867	115.667	213.500	260.083	227.750	231.583	254.408	262.110	280.647	287.083	229.166	177.000	203.143
L5	135.454	185.666	253.667	247.749	230.835	217.165	233.175	245.355	295.868	266.333	206.915	162.500	206.591
L6	202.536	227.335	366.165	337.335	274.916	377.750	421.934	429.694	432.544	574.916	411.910	312.416	336.573
L7	148.399	187.333	249.500	225.416	265.000	342.916	370.866	378.222	379.312	211.335	181.166	144.167	237.741
L8	197.064	202.167	361.333	216.165	177.165	221.083	239.836	245.890	247.331	123.833	103.165	92.750	187.368
L9	201.470	235.500	315.167	288.166	213.167	285.250	301.679	317.226	381.626	170.916	135.500	119.165	228.756
L10	240.355	265.500	323.666	225.165	192.333	251.583	283.329	288.454	289.251	117.500	86.915	88.583	204.818
L11	197.225	236.335	377.165	323.916	274.000	416.085	449.946	476.997	496.450	214.916	162.666	122.083	289.237
L12	160.777	168.667	203.000	125.333	144.665	165.335	173.892	171.695	179.595	141.999	116.749	96.999	143.131
L13	210.385	250.166	318.166	253.917	258.417	350.417	345.080	355.288	322.297	261.000	179.750	130.495	249.875
L14	145.750	169.000	225.165	231.749	238.834	301.667	283.456	296.224	304.251	215.749	166.245	127.583	209.205
L15	132.258	134.500	219.000	245.500	232.333	273.916	309.253	347.625	354.514	249.165	163.665	126.833	215.658
L16	114.275	152.000	197.333	208.335	213.000	274.583	295.045	297.147	299.225	282.416	189.750	140.665	206.136
L17	165.000	150.500	236.500	240.000	250.665	284.500	296.394	299.256	303.666	169.083	112.916	72.083	199.812
L18	195.274	283.166	361.665	349.333	326.417	496.917	669.339	688.346	687.291	438.333	352.833	256.249	394.089
CD	73.146	85.059	132.009	90.426	NS	205.69	225.74	207.35	217.48	130.878	105.731	83.9197	

496.917 cm^2). Yellow bees from L18 showed the highest mean honey storage area from February to April (669.339, 688.346, 687.291 cm^2 respectively) which were on par with that of black bees from L3. Highest honey storage area (574.916 and 540.083 cm^2) was recorded in black bees from L6 and L3 during May. Comparatively low honey area was observed in colonies with common brown bees than the black and yellow bees.

Table 6. Honey yield (kg) in *Apis cerana indica* colonies collected from different locations of Kerala during honey flow season 2013

Location	Mean honey yield (kg)	Location	Mean honey yield/ colony (kg)
L1	6.416	L10	5.916
L2	11.016	L11	20.642
L3	17.858	L12	7.292
L4	7.833	L13	10.500
L5	6.800	L14	10.408
L6	17.000	L15	7.833
L7	9.958	L16	6.559
L8	6.200	L17	4.708
L9	9.458	L18	18.183

CD 5.6376

Average honey yield (Table 6) was also more in yellow bee colonies from L11 (20.642 kg), L18 (18.183 kg) and black bees from L3 and L6 (17.858 kg and 17.00 kg) and the yield in all were on par. The honey yield in common brown bees ranged from 4.708 kg-11.016 kg only.

e. Disease incidence and absconding behavior

The observations on incidence of disease and absconding/desertion of colonies are presented in Table 7. The results showed that no colonies absconded during August 2012 while during next month (September) one colony from L13 absconded. During October one colony each from L5 and L14 absconded due to disease. In November, 2012 one colony each from L1, L8 and L10 and two colonies from L12 absconded. One colony each from L1, L6, L8 and L10 absconded during December, while the desertion from L6 was not due to disease infection. One colony from L5 and L15 absconded during February and one colony from L12 during March. One colony from L6 absconded in April and it was not due to disease. In May three colonies absconded one each from locations L2, L3 and L16. During next month four colonies absconded one each from L3, L6, L8 and L17. During July one colony absconded from L15. From L3 and L6, three colonies each absconded and none of them had any disease infection, whereas from L5, two colonies absconded due to disease, one during February 2013 and the other during July 2013. Maximum number (5) of colonies absconded during November followed by December and June (4 nos. each) and minimum during March, April and July and September

Table 7. Disease incidence and absconding of *A. cerana indica* colonies (No.) collected from different locations during 2012-13

Locations	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	No. of colonies absconded
L1	-	-	-	D/A (1)	D/A (1)	-	-	-	-	-	-	-	2
L2	-	-	-	-	-	-	-	-	-	D/A (1)	-	-	1
L3	-	-	-	-	-	A (1)	-	-	-	A (1)	A (1)	-	3
L4	-	-	-	-	-	-	-	-	-	-	-	-	0
L5	-	-	D/A (1)	-	-	-	D/A (1)	-	-	-	-	-	2
L6	-	-	-	-	A (1)	-	-	-	A (1)	-	A (1)	-	3
L7	-	-	-	-	-	-	-	-	-	-	-	-	0
L8	-	-	-	D/A (1)	D/A (1)	-	-	-	-	-	D/A (1)	-	3
L9	-	-	-	-	-	-	-	-	-	-	-	-	0
L10	-	-	-	D/A (1)	D/A (1)	-	-	-	-	-	-	-	2
L11	-	-	-	-	-	-	-			-	-	-	0
L12	-	-	-	D/A (2)	-	-	-	D/A (1)		-	-	-	3
L13	-	D/A (1)	-	-	-	-	-	-	-	-	-	-	1
L14	-	-	D/A (1)	-	-	-	-	-	-	-	-	-	1
L15	-	-	-	-	-	-	D/A (1)	-	-	-	-	D/A (1)	2
L16	-	-	-	-	-	-	-	-	-	D/A (1)	-	-	1
L17	-	-	-	-	-	D/A (2)	-	-	-	-	D/A (1)	-	3
L18	-		-	-	-	-	-	-	-	-	-	-	0
Total	0	1	2	5	4	3	2	1	1	3	3	1	

D/A – Diseased and absconded, A – Absconded due to some other reason, ( ) Number of colonies absconded

(one colony each). The results showed that three black bee colonies each from L3 and L6 absconded and none of them had any disease infection and no yellow bee colonies absconded from L11 and L18.

DISCUSSION

The black and yellow morphs of *A. cerana indica* is being reported from Kerala for the first time. Oldroyd *et al*. (2000) reported that *A. cerana* population in Karnataka is composed of two distinct colour morphs: the yellow 'plain' morph and the black 'hill' morph. Later, Banakar (2009) reported that the black 'hill' morph is distributed in Uttara Kannada, Udupi, Dakshina Kannada, Shimoga, Kodagu, parts of Dharwad, Belgaum, Mysore and Chamarajanagar districts. Shruthi *et al.,* 2009 also studied the behavioural traits of two colour morphs from Karnataka. Eventhough, Devanesan (1998) reported four ecotypes of *A. cerana indica,* from Kerala, based on multivariate analysis of 50 morphometric characters, black and yellow morphs were not observed.

The comparative performance on economically important desirable characters of *A. cerana indica* colonies selected from different locations showed that yellow bees and black bees were significantly superior in all the characters including honey production compared to common brown bees.

Maximum bee strength was recorded in black bees and yellow bees compared to common brown bees. This agreed with the report of Shruthi *et al*., (2009) who reported that in Karnataka, bee population in both black and yellow strain colonies of *A. cerana indica* were more and among the strains, black strain colony recorded higher bee population compared to yellow strain colony. Brood area was also higher in both black bees and yellow bees compared to brown bees. Banakar, 2009 reported that brood area in both yellow and black colour morphs was not significantly varying and both colour morphs performed equally exhibiting similar brood growth in Karnataka.

In pollen collection the black and yellow bees do not show significant superiority over the brown bees. It agrees with the report of Banakar, 2009 who revealed that comparative performance of pollen gathering activity in terms of pollen area in colonies of both yellow and black colour morphs exhibited no significant difference. Both the colour morphs performed in similar way in increasing the pollen store area. While Shruthi *et al*., 2009 reported that the black strain showed better performance than yellow strain in pollen storage under Karnataka conditions. This variation may be due to climatic conditions and flora available in the states.

Both yellow and black morphs recorded higher honey storage area than the common brown bees but among the morphs it was high in yellow bees compared to black bees. Similar results were reported by Banakar (2009) from Karnataka. Shruthi *et al*. (2009) reported that black strain and yellow strain of *A. cerana indica* colonies under Shivamogga, Karnataka conditions, both strains stored higher amount of honey and among the strains, black strain recorded more

honey stores compared to yellow strain. These differences observed may be due to variation in genetic character, in bee flora, climatic conditions of different states. In the present study, average honey yield was seen very high in yellow bee and black bee colonies compared to common brown bees.

The black bees and yellow bees had more tolerance/ immunity against diseases compared to common bees. Devanesan (2006) reported that all the ecotypes of *A. cerana* in Kerala are susceptible to TSBV. Amritha *et al*., 2012 reported a new disease incidence from *A. cerana* colonies in Kerala during 2011. No absconding behavior recorded in yellow bees while it was more in black and common bees. The study suggest that the black and yellow morphs with desirable characters can be utilized for selective breeding for production of better performing colonies for commercial beekeeping and enhanced honey production in Kerala.

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