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Evaluation of hive wood types for Indian honey bee *Apis cerana indica*

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Abstract
A study was carried out to compare seven different wood types for hive making in respect of colony growth characteristics such as sealed brood area, pollen storage and sealed honey area in Indian honey bee *Apis cerana indica* in the Apiary of department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore during 2022. A six-frame hive type was used in this study which had the bottom board, brood chamber with six frames, shallow super chamber with six frames, inner lid and outer lid. In order to test the wood type suitable for making hives, a total of twenty-one hives made from seven different wood types namely Malai Vembu (*Melia dubia)*, Teak (*Tectona grandis*), Vengai (*Pterocarpus marsupium*), Acacia (*Acacia nilotica*), Vagai (*Albizia lebbeck*), Rubber (*Hevea brasiliensis*), and Punnai (*Calophyllum inophyllum*) were prepared with three hives in each wood type serving as replication. The temperature maintained inside the hives were recorded which were on par in various wood types. Studies on colony growth parameters in these seven different wood types revealed that Malai Vembu (*Melia dubia*) recorded the maximum values of sealed brood area of 785.5 cm^2, pollen storage area of 169.7 cm^2, honey storage area of 405.1 cm^2 at 90 days from the start of the experiment which were significantly higher than other wood types. In addition, hives made of Malai Vembu (*Melia dubia)*, were light in weight compared to other wood types which can be helpful during migration of hives by beekeepers.

Keywords: *Apis cerana indica*, brood area, pollen storage, honey area, wood hives

Introduction
Apis cerana indica Fab. is an indigenous bee species found in nature that is employed for commercial beekeeping and honey production in south India. *A. cerana indica* (also known as the Asian honeybee, Asiatic bee, Asian hive bee, Indian honeybee, Indian bee, Chinese bee, Mee bee, Eastern honeybee, and Fly Bee) is an endemic Asian honeybee that has been utilised for honey production and pollination over centuries. *A. cerana* populations can be separated into three sub-species, according to studies conducted by the International Centre for Integrated Mountain Development (ICIMOD), namely *Apis cerana cerana*, *Apis cerana himalaya*, and *Apis cerana indica*. Beekeepers can achieve their goals of increased honey, wax, propolis, pollen, and venom production, as well as improved crop productivity through crop pollination, by expanding the number bee colonies. The colony performance parameters, which include the number of workers, the amount of brood, pollen and honey store as well as artificial feeding, influences the foraging pattern. Brood rearing is an essential activity of bee colonies (Chaand *et al*, 2017) [3]. The ability of a honey bee colony to combat pests and withstand diseases is determined by the colony's strength (Kasangaki *et al*, 2018) [5]. Honey bee productivity is highly dependent on the strength of a honey bee colony (Sharma *et al*, 2018) [8]. Pollen is the main source of several key nutrients for the honey bees. As a result, sufficient pollen supply is required to ensure a colony's long-term life and productivity. Ingestion of high-quality pollen stimulates the development of the hypopharyngeal glands in immature honey bee workers (Irene keller *et al.*, 2005) [6]. Improving the performance of the hive bees can be achieved by keeping them in suitable beehives. Honey bee populations can be made more comfortable in their hives by employing materials that can maintain desirable temperature and humidity (Erdogan *et al.*, 2019) [4]. The qualities of wood, as an important biological raw material, define their greatest industrial applications. To determine honey bee wood preference for nesting, studies focus on the colours and non-structural chemical characteristics of the woods (Adedeji *et al*., 2014) [1]. The goal of the present study was to determine the suitability of the hive types and the wood types used in hive making on the

temperature and humidity maintenance inside the hive, ease of migration and ultimately the colony performance namely honey and pollen storage in hive and brood rearing.

Materials and Methods

Description of the study area

The current study was conducted in the apiary of Department of Agricultural Entomology, (latitude 11˚.01' N and longitude 76˚.92' E) Tamil Nadu Agricultural University Coimbatore in 2022.

Wood types for hive construction

Seven different types of wood materials that were chosen based on their cost efficiency, durability, and density namely T_1- Malaivembu or Malabar Neem (*Melia dubia*), T_2-Teak (*Tectona grandis*), T_3- Acacia (*Acacia nilotica*), T_4- Rubber (*Hevea brasiliensis*), T_5- Vengai or Indian kino (*Pterocarpus marsupium*), T_6- Punnai or Alexandrian laurel (*Calophyllum inophyllum*) and T_7 Standard- Vagai or lebbek tree (*Albizia lebbeck*), and three hives per wood type were maintained as replications. Vagai (*A. lebbeck*) was taken as standard as this wood is commonly used for making bee hives in Tamil Nadu. Hence a total of twenty one established colonies of *A. cerana indica* were selected and maintained in a hive with a bottom board having alighting space, brood chamber with six frames, shallow super chamber with six frames, an inner lid and an outer lid. The colonies were then adjusted to have six frames in each chamber (Figure 1).

Keeping of the beehives

The beehives were kept in the apiary with the metallic stand. The hives were placed in fields having similar bee forage or plants with similar resources for the bees (figure 2) The positions of frames labelled 1, 2, and 3 etc. were noted for identification purposes, and observations were recorded. The observations in each of the selected frames were recorded in all of these hives at fortnightly intervals.

Colony growth parameters

Colony growth parameters such as sealed brood area (cm^2), pollen area (cm^2), sealed honey area(cm2), and bee strength were recorded in all colonies using a grid set on a frame at 14-day intervals.

Area of sealed brood

The area of wax-capped cells containing pupae, also called sealed brood was measured on both the sides of frames using the OHP transparent sheet with grid of markings of 1 × 1 cm^2. The total sealed brood area in cm^2 was calculated in each colony by finding out the total number of 1 x 1 cm^2 squares covering the brood area in all the frames (Figure 3)

Area of pollen storage

Pollen is the primary source of protein to honey bees. Stored pollen is the nutritionally rich currency used for colony growth. The pollen storage area was measured on the both sides of the frames in each colony by using the OHP sheet with grid markings as mentioned above and expressed in cm^2.

Area of sealed honey

Honey bees make honey to store up as food to last them through the winter months. The sealed honey area can be differentiated where the cells are slightly transparent and sunken compared to the sealed brood area. The sealed honey area was calculated by using the OHP sheet with grid markings as mentioned above and expressed in cm^2.

Hive temperature

The hive temperature was recorded with the help of a thermometer that was placed in-between the combs (Figure 4). The temperature was recorded at 10.00 am in different hives on three consecutive days during April 2022 and the mean was worked out.

Hive weight /density

The weight of the hive consisting of bottom board, brood chamber, super chamber, inner and outer lid was recorded for hives all wood types for three hives in each type and the mean was calculated (figure 5). The difference in hive weights were proportionate to the density of the wood types used as the volume of wood used was the same for all the hives (as density=mass/volume).

Statistical analysis

The experiment was set up according to a factorial completely randomized block design with three replication. Data were analysed using the ANOVA (Analysis of Variance) and least significant difference (LSD) was performed at $P < 0.05$ levels of significance. Correlation analysis and test for significance were performed between hive temperature / hive weight and colony growth parameters.

Results and Discussion

Effect of different wood types on sealed brood rearing by Indian honey bees

The mean sealed brood area in all six month of observation revealed that the treatment T_1, Malai Vembu (*M. dubia)* recorded the maximum area of 785.5 cm^2 followed by T_7 (Standard –Vagai, *A. lebbeck*) 736.3 cm^2 of sealed brood area (Table 1). The other wood types recorded sealed brood area that was lower than T_7. Among the periods of observation, the highest level of sealed brood area was recorded during 15th April during 2022 with a mean value of 868.85 cm^2. The lowest mean sealed brood area 326.43 cm^2 was recorded during 1st February 2022. There was an increase in the sealed brood area in all the hives due to the start of honey flow season.

Effect of different wood types on honey storage area by Indian honey bees

While **c**omparing the effect of different wood types on of honey storage area in the combs by Indian honey bees, the maximum honey storage area was recorded in the colonies kept in Malai Vembu (*M. dubia)* wood type with an overall mean of 405.1 cm^2 which was statistically better than all other treatments (Table 2). Vagai (*A. lebbeck*) and Acacia (*A. nilotica*) also gave good performance as the honey storage area recorded was 381.7 cm^2 and 361.80 cm^2. Minimum honey storage area of 260 cm^2 was recorded in the Rubber (*H. brasiliensis*). The honey storage area also varied among the different periods of observation. The maximum honey storage area was observed on 15th April 2022 in all the colonies while the minimum honey storage area was observed on 1st February.

Effect of different wood types on pollen storage area by Indian honey bees

The effect of different wood types on the colony performance parameter namely the pollen storage area was studied in the Indian honey bee. The mean pollen storage area in all the observations revealed that the treatment T_1 Malai Vembu (*M. dubia)* had the highest overall mean pollen storage area of 169.7 cm^2. This was followed by T_7 Vagai, *A. lebbeck* (152.0 cm^2) and T_3 Acacia, *A. nilotica* (138.7 cm^2) The observations recorded in 1st February with an overall mean of 55.14 cm^2. There was an increase in pollen storage area in the periods of 15th April 2022 (185.81 cm^2).

Effect of physical properties of hive on colony performance

The physical properties of hive on colony performance were presented in the table 5. Hive temperature recorded between combs was lowest in *A. nilotica* (34.8 ºC) and *M. dubia* (34.9 ºC) and highest in *Albizia* (36.8 ºC). There was a non-significant negative correlation between hive temperature and colony performance, the R^2 value being 0.06 to 0.09 indicating that lower the hive temperature, better was the colony performance but the relation was non-significant.

The hive weight (which is proportionate to the wood density) was significantly different among different hives with *A. nilotica* being the heaviest (7.378 kg) while *M. dubia* being the lightest 4.076 kg. However, there was non-significant positive correlation between hive weight / density and colony performance the R^2 value was less than 0.01 meaning that higher the wood density, higher the colony performance but it was non-significant.

Okyere-Amoateng *et al*., (2021) [7] found that in terms of honey, beeswax, and propolis yield, bee hives made of woods namely *Tectona grandis* and *Terminalia superba* performed admirably. *T. grandis* wood is suitable for beekeeping, according to the findings. Adedeji *et al*., (2014) [1] reported that white woods (*Gmelina arborea* and *Vitex doniana*) were shown to be acceptable as cavity materials for honeybees nesting over brown wood (*Erythrophleum suaveolens*). Adedeji *et al*., (2014) [2] reported that seasons have an important role in colonisation, and the wood, *Triplochiton scleroxylon* was appropriate but prone to insect attacks. Worker activity and metabolism influence changes in CO_2 and O_2 concentrations inside the hive. Because energetic bees have a higher body temperature, their activity level may influence the release (e.g., evaporation) of extra compounds. Bloch *et al*., (2020) [9] reported that hive volatiles mediate social synchronization in honey bee colonies. In our studies, it was found that compared to all other wood kinds, the light weighted wood, Malai Vembu (*M. dubia)* was more appealing to bees and aided in increased brood raising, pollen storage area, and honey storage.

Table 1: Effect of hive wood types on brood development in Indian honey bee (TNAU, Coimbatore, 2022)

Tr.No	Treatment (Hive Wood types)	Pretreatment 15th Jan	Sealed brood area (cm^2)						
			Post treatment (Days after transferring to hive)						
			1st Feb	14th Feb	1st Mar	15th Mar	1st Apr	15th Apr	Mean
T1	*Melia dubia*	265.0	463.50 a	635.50 a	786.0 a	864.0 a	942.00 a	1022.00 a	785.5a
T2	*Tectona grandis*	261.5	298.00 d	496.50 d	616.5 d	714.0 d	785.20 d	865.20 c	629.2 d
T3	*Acacia nilotica*	264.0	386.50 c	560.50 c	696.5 c	774.0 c	856.40 c	945.60 b	703.3 c
T4	*Hevea brasiliensis*	271.5	205.00 f	389.00 g	486.0 g	577.0 g	638.50 g	716.40 f	502.0 g
T5	*Pterocarpus marsupium*	255.5	240.50 e	417.00 f	535.0 f	612.0 f	686.80 f	756.80 e	541.4 f
T6	*Calophyllum inophyllum*	262.0	274.00 d	452.00 e	586.0 e	658.0 e	726.40 e	812.60 d	584.8 e
T7	*Albizia lebbeck* (Standard)	261.5	417.50 b	592.50 b	736.0 b	817.0 b	891.30 b	963.40 b	736.3 b
	Mean	263.0 ns	326.43 F	506.14 E	634.57 D	716.57 C	789.51 B	868.85 A	
	Treatment CD (0.05)	10.52 (S)							
	Period CD (0.05)	9.74 (S)							
	T X P CD (0.05)	25.77 (S)							

Table 2: Effect of hive wood types on honey storage by Indian honey bee (TNAU, Coimbatore, 2022)

S. No	Treatment (Hive Wood types)	Pretreatment 15th Jan	Sealed Honey Area (cm^2)						
			Post treatment (Days after transferring to hive)						
			1st Feb	14th Feb	1st Mar	15th Mar	1st Apr	15th Apr	Mean
T1	*Melia dubia*	25.5	56.20a	148.50a	306.0a	481.0a	664.50a	774.50a	405.10a
T2	*Tectona grandis*	24.5	38.10a	110.60a	239.5c	379.5d	572.30d	664.30d	334.10d
T3	*Acacia nilotica*	22.0	43.80a	124.80a	279.5b	421.5c	608.40c	692.60c	361.80c
T4	*Hevea brasiliensis*	27.5	30.90a	86.40a	158.5e	193.5f	492.20f	598.50f	260.00g
T5	*Pterocarpus marsupium*	23.5	32.40a	91.30a	188.0d	199.5f	506.50f	614.10f	272.00f
T6	*Calophyllum inophyllum*	26.0	35.30a	102.20a	195.0d	225.5e	534.60e	641.80e	289.10e
T7	*Albizia lebbeck* (Standard)	22.5	48.6a	132.40a	301.0ab	442.5b	633.20b	732.40b	381.70b
	Mean	24.5 ns	40.76 F	113.74 E	238.21D	334.71C	573.10 B	674.02 A	
	Treatment CD (0.05)	7.25(S)							
	Period CD (0.05)	6.71(S)							
	T T X P CD (0.05)	17.75(S)							

Table 3: Effect of hive wood types pollen storage by Indian honey bee (TNAU, Coimbatore, 2022)

Tr. No	Treatment (Hive Wood types)	Pretreatment 15th Jan	Pollen storage area (cm^2)						
			Post treatment (Days after transferring to hive)						
			1st Feb	14th Feb	1st Mar	15th Mar	1st Apr	15th Apr	Mean
T1	*Melia dubia*	38.5	84.00_{a}	130.00_{a}	170.5_{a}	186.5_{a}	210.50_{a}	236.40_{a}	169.70_{a}
T2	*Tectona grandis*	42.0	46.50_{c}	85.00_{d}	94.5_{d}	120.4_{d}	146.40_{d}	188.30_{d}	113.50_{d}
T3	*Acacia nilotica*	37.0	68.50_{b}	106.00_{c}	132.0_{c}	146.2_{c}	174.60_{c}	204.70_{c}	138.70_{c}
T4	*Hevea brasiliensis*	48.5	29.50_{e}	53.00_{f}	62.5_{g}	84.5_{g}	106.50_{g}	142.50_{g}	79.80_{g}
T5	*Pterocarpus marsupium*	36.0	37.00_{d}	70.50_{e}	78.0_{f}	92.4_{f}	114.50_{f}	148.10_{f}	90.10_{f}
T6	*Calophyllum inophyllum*	45.0	39.00_{d}	71.00_{e}	84.0_{e}	102.8_{e}	128.90_{e}	164.20_{e}	98.30_{e}
T7	*Albizia lebbeck* (standard)	31.5	81.50_{ab}	119.50_{b}	149.5_{b}	158.6_{b}	186.40_{b}	216.50_{b}	152.00_{b}
	Mean	39.8 ns	55.14_{F}	90.71_{E}	110.14_{D}	127.34_{C}	152.54_{B}	185.81_{A}	
	Treatment CD (0.05)	2.12(S)							
	Period CD (0.05)	1.96(S)							
	T X P CD (0.05)	5.19(S)							

Table 4: Hive weight of seven different wood types for *Apis cerana indica and* temperature maintained inside the hive

	Wood types	Hive weight (kg) *	Hive temperature (ºC)
T1	*Melia dubia*	4.076 a	34.9_{a}
T2	*Tectona grandis*	5.432 f	36.2_{b}
T3	*Acacia nilotica*	7.378 g	34.8_{a}
T4	*Hevea brasiliensis*	4.709 cd	35.7_{ab}
T5	*Pterocarpus marsupium*	4.860 de	36.0_{bc}
T6	*Calophyllum inophyllum*	5.016 e	36.0_{bc}
T7	*Albizia lebbeck* (Standard)	4.507 bc	36.8_{c}
	CD (0.05)	0.242	1.0

*The hives with bottom board, brood chamber. Super chamber top inner and outer cover but without frames were weighed

Table 5: Correlation coefficient (R) and coefficient of determination (R^2) of physical properties of hive (Hive temperature and hive weight / density) with colony performance parameters (Brood area, honey and pollen storage area)

Physical properties	Sealed brood area		Sealed honey area		Pollen area	
	R	R^2	R	R^2	R	R^2
Hive temperature	-0.24 ns	0.06	-0.25 ns	0.06	-0.30 ns	0.09
Hive weight /density	+0.09 ns	0.01	+0.09 ns	0.01	+0.10 ns	0.01

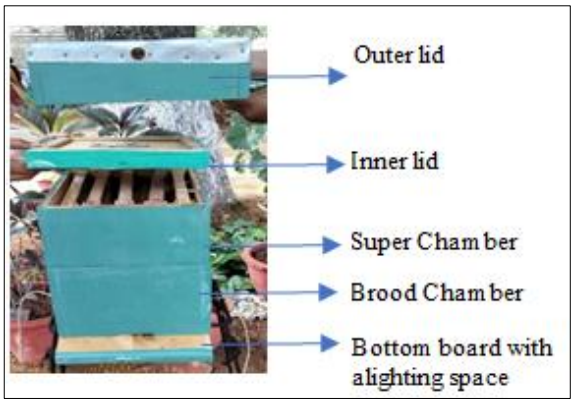

Fig 1: Hive shown with its components

Fig 2: Hives placed in the field

Fig 3: Assessing colony growth parameters using Transparent OHP sheet with grid markingt

Fig 4: Recording hive temperature using digital thermometer

Fig 5: Recording hive weight

Conclusion

The results of our investigation indicate that, the Indian honey bees, *A. cerana indica* grew well in Malai Vembu (*M. dubia)* out of the various wood kinds tested, leading to increased brood raising, pollen storage area, and honey storage. In addition, the lowest wood density and the light weighted hives made of *M. dubia* will aid in easy migration of bee colonies from one location to the other and can reduce the drudgery of beekeepers while lifting bee hives. Further studies may throw light on the influence of any wood based hive odour / volatiles present or absent in *M. dubia* that might favour better colony performance.

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