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Full Length Research Paper

Colony status of Asian giant honeybee, *Apis dorsata* Fabricius in Southern Karnataka, India

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The field survey conducted to collect more than twenty parameters of *Apis dorsata* colonies during different seasons at different districts of southern Karnataka revealed interesting results. Altogether, 2,407 normal colonies (comb with live bees) were recorded at various habitats of southern Karnataka. Of all, Mysore district has recorded highest (1,560) colonies followed by Chamarajanagar (544) and Kodagu (303) districts. Among the seasons, winter has recorded highest (839) colonies followed by rainy (807) and summer (761) seasons. *Apis dorsata* selected 20 tree species to nest 1,646 colonies at an elevation ranged from five to 80 feet. About 580 colonies nested on human built structures at the height of eight to 75 feet and 181 colonies were found on rock cliffs at 10 to 30 m elevation. The colony density was more (3.64) in Mysore district followed by Chamarajanagar and Kodagu districts. Accordingly, the abundance and percent nesting frequency were also varied considerably. Further, the colony aggregates, aggregates density per 5^2 meter area, abundance and percent frequency was 1.57, 3.19 and 134.07 respectively on trees, rock cliffs and human built structures at Chamarajanagar, Kodagu and Mysore districts. The morphometrics indicated considerable variations. *A. dorsata* produced multifloral honey (10,831.5 kg) and good quantity of beeswax (1,444.2 Kg) every year. The floral source included 687 flowering plants which belong to 223 familes, supplied continuous nectar flow during most of the seasons with little variations. *Apis dorsata* honey quality was moderate with below detection limit of pesticide residues. Continuous interference from various predators, pests and parasites along with man-made activities have stressed severely *A. dorsata* colony population which resulted in the colony decline considerably. Thus, there is a dire need to conserve *A. dorsata* population under natural conditions in this part of the state.

Key words: Colony status, Apis dorsata, southern Karnataka, India.

INTRODUCTION

In India, different *Apis* species occur at various agro-ecosystems. Among them the Asian giant honeybee, *Apis dorsata* Fabricius (Hymenoptera: Apidae: Apoidea) pollinators, produce multifloral honey, which contributes more than 80% to the total honey production in India (Bradbear and Reddy, 1998). In Karnataka, it is locally called 'Hejjenu', which is known for its big-sized colonies, ferocious behaviour and venomous sting to man and is a large feral insect (Engel, 1999) distributed unevenly at diversified ecosystems in the wild. It is one of the major livestock at various farm lands, forests and human inhabited ecosystems. Although reports are available on *A.dorsata* hive products (ex. Honey and beeswax) at certain regions of Karnataka, information on beeswax production, pests, predators, pathogens, pesticide poisoning, honey hunting and other unwanted human activities are sparse. Moreover, the overall colony status is not properly explored. Since, *A. dorsata* is one of the largest bees in the genus *Apis* (Oldroyd et al., 2000), build vertical colonies, which often found in dense

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aggregations (Dyer and Seeley, 1994) under arboreal conditions such as on the eaves of tall tree limbs, rock cliffs and human built structures (Reddy, 2002; Seeley et al., 1982) at an inaccessible elevations (Hepburn and Hepburn, 2007; Tan, 2007). Recording *A. dorsata* colonies and revealing their status requires multifaceted approach. In this regard, reports on the colony distribution at various habitats, potential nest host trees, foraging source, production of multifloral honey, honey quality and contamination, honey harvest and prevailed biological constraints at nest sites of *A. dorsata* from southern Karnataka are scanty. There exists a lacuna of understanding the full potential of *A.dorsata* population in this part of the state.

Further, *A. dorsata* is known for its migratory behaviour, it gathers high amount of honey upto 45 kg from a single colony (Ruttner, 1988; Vinutha, 1998). Therefore, recording nest host trees, nesting sites at hilly areas and human inhabited ecosystems are essential to quantify *A. dorsata* hive products. Moreover, honey is harvested from the combs of *A. dorsata* during specific seasons and hence honey can be harvested seasonally (Paar et al., 2004) and that shows greater variation in composition and characteristics (Anklam, 1998; Anupama et al., 2003; Joseph et al., 2007). However, in Karnataka honey is harvested from *A. dorsata* combs by conventional methods (Setty and Bawa, 2002), honey hunters give least importance to clean and hygiene while honey preservation. Further, nest architecture matters a lot while yielding good amount of honey. Does

A. dorsata construct different shaped combs? Neither an influence of celestial cues for specific orientation of combs nor to protect from biological and environmental factors, scientific data are required to reveal information on such facts. Moreover, reports are available on variety of both invertebrate and vertebrate predators or parasites or pests including 40 different speices of birds (Abrol, 2003;Nagaraja and Rajagopal, 2011; Morse and Laigo, 1969), which cause severe damage to *A. dorsata* colonies (Nagaraja and Rajagopal, 2011). Reports on the extent of colony decline and colony status at this part of the state during different seasons are not available. Thus, this has necessitated the scientific reports and impelled us to conduct the detailed study on the colony status of *A. dorsata*. By considering various parameters, multifaceted approach was made and the results of such findings are presented in this paper.

MATERIALS AND METHODS

Study area

The field survey was conducted during 2008 to 2011 by selecting13 taluks in Chamarajanagar, Kodagu and Mysore districts of southern Karnataka. These districts lies in between 11° 92′ to 12° 52′ N latitude and 72° 22′ to 76° 95′ E longitude at an elevation of more than 867.33 meter above msl and located amidst the vicinity of south-western parts of Western Ghats covered by rich floral source and represents the high degree of biological activity (Figure 1) (Kamath, 2001). The physiographic and meteorological details of the study area are depicted in Table 1. During field study, pre-tested questionnaire was prepared by including more than twenty parameters, namely occurrence of *A. dorsata* normal colonies at various habitats during different seasons, normal colony density, abundance, percent frequency of colony establishment, number of colony aggregates per bee tree, comb morphology, hive products (ex. Honey and beeswax) potential nest host tree species, nesting habitat, nesting elevation, floral source, physico-chemical characters of multifloral honey, honey quality and contamination, methods of honey harvest, possible causes stressing on the survival of *A. dorsata* and reason for colony decline were considered. Each parameter was further divided into various sub groups depending on the need and importance. Several agricultural ecosystems, rock cliffs at Male Mahadeshwara Hills, Biligiri Ranganath Hills, Chamundi Hills and human inhabited places were periodically visited during different seasons. While collecting information, specific methods were followed as and when required and the images of certain parameters were taken with the help of Canon-Power Shot S21S, 8.0 Mega Pixels Digital Camera with 12X Optical Zoom.

The normal colony density, abundance and frequency of colony establishment on different trees, rock cliffs and human built structures (HBS) were calculated as per the method of Phillips (1959) after little modification. Normal colony density = Total no. of normal colonies recorded/total no. of study sites visited to record the normal colonies. The normal colony abundance = Total no. of normal colonies recorded/ number of study sites where normal colonies observed. The frequency of colony establishment = No. of times colonies found at a particular study site/total number of observations made at each study site × 100. The nesting elevation was measured as per Krishnamurthy (2001). To record the comb aggregates, 25 sampling sites were randomly selected in each districts and in each sampling site, various nest host trees located at garden, cultivable land, on either sides of the road, on rock cliffs and various HBS were observed as per Woyke (2008) from a distance of 25 to 50 m. As comb aggregations were confined to few limbs of bee trees, on some parts of rock cliffs and HBS, only 5^2 m imaginary area was considered and photographed. Number of colonies was counted by using adobe software version CS3 and digital video camera with 16X Optical Zoom and recorded noteworthy variations (ex. shape of comb, size, comb length, width, cell depth, cell area and honey storing capacity in honey chamber and brood chamber) from the normal colonies (Vinutha, 1998; Shukla and Upadhya, 2007).

The weight of abandoned comb was taken before boiling it in water at 60°C. After boiling, the molten wax was filtered, smeared on silver plate and again the weight of dried wax was taken. Moreover, the causes for the abandonment of *A. dorsata* colonies were recorded. Nest host trees were observed at 114 sampling sites both by naked eyes and using a binocular (10 × 50X) by selecting one kilometer length Variable Width Line Transects (VWLTs) (Burnham et al., 1980). The trees were photographed and identified by using both photographic pictures and the methods as described by Gamble (1967). Moreover, foraging plants were recorded with the help of information as described by Gamble (1967) and Rao (1973). The foraging plants were further grouped into various types so as to reveal their percent occurrence.

The predators or pests were recorded at the vicinity of *A. dorsata* colonies by considering different lengthen VWLT's with a width of 50 feet as devised by Abrol (2003), Nagaraja and Rajagopal (2011). Total 125 VWLT's were selected and predators, pests were identified by following standard methods as described by Nagaraja and Rajagopal (2011) and Hepburn and Radloff (2011). To record parasitic mite's infestation, Mysore city was selected randomly and field observations were made on weekly basis between 0800 and 1200 h during September, 2008 to June, 2010. The worker bees

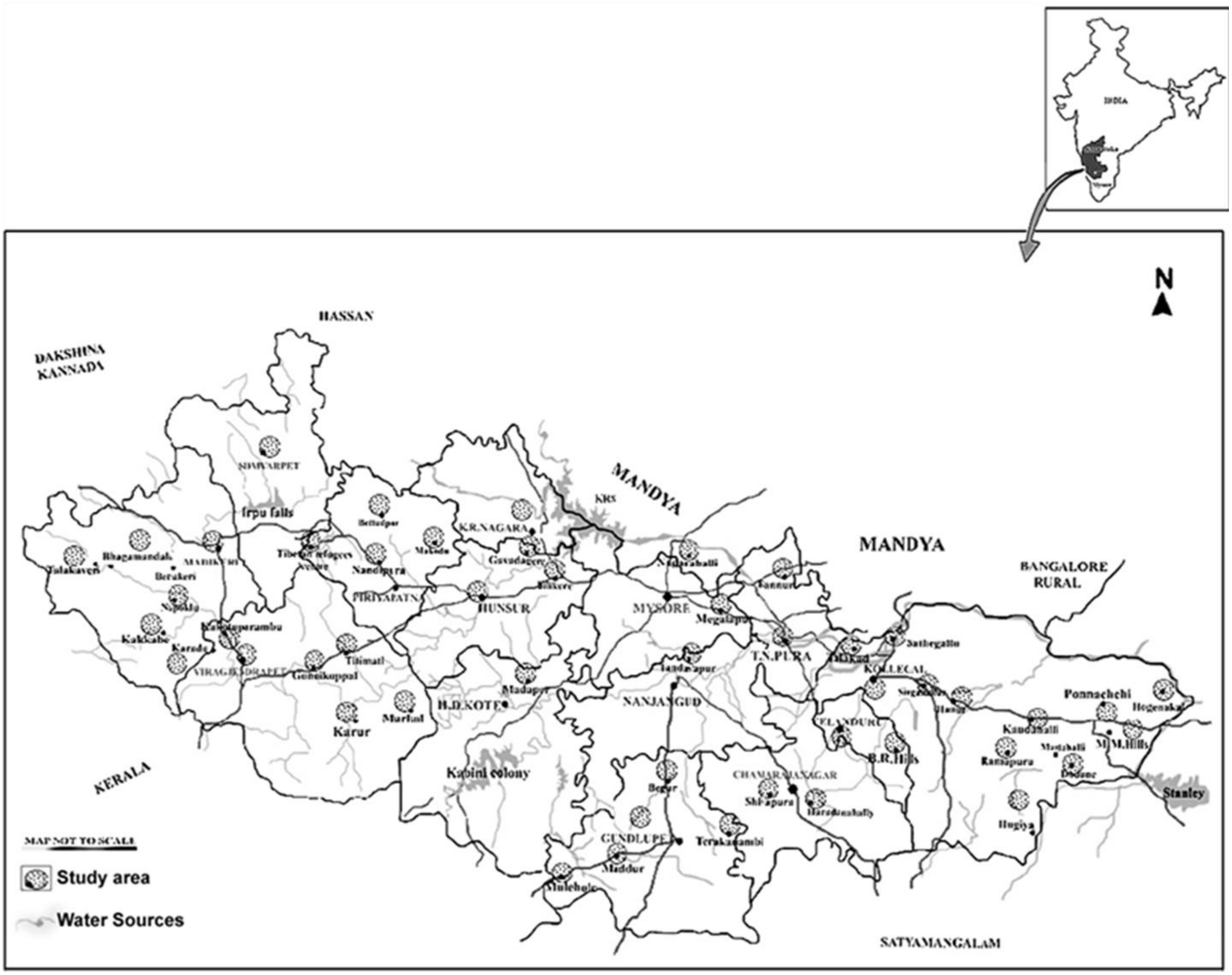

Figure 1. Study areas in southern Karnataka.

suspected to be infested with parasitic mites were collected from various places, that is, nearby nesting trees, trees in scrubby vegetation and at HBS by random sampling method. Total 80 observations were made periodically by using adult worker bees during their foraging in filed and in hive too. The infested bees were collected from honey hunters after the comb harvest and observed under Leica EZ4 Stereozoom microscope. The phoretic mites were recorded from different body parts of adult worker bees. Further, the parasitic wax moth infested normal and abandoned colonies were observed both by naked eyes and using a binocular (10 x 50X) and photographed by making imaginary quadrate (5^2 m) from 114 Line Transects. The incidence of predators, pests, parasites and pathogens of *A. dorsata* was made as per Abrol (2002, 2003) and Bailey and Ball (1991). As the vegetation distribution was not uniform at different districts of southern Karnataka, an all out search method (AOSM) was also adopted during the field survey. Moreover to reveal the quality and contamination of multifloral honey, the physico-biochemical parameters (ex. pH, specific gravity, electrical conductivity, absorbance and turbidity, glucose, fructose and invert sugar and total protein content) were estimated as per Ouchemoukh et al. (2007). Further, sixteen *A. dorsata* honey samples were collected randomly from the study area and stored in airtight plastic containers until analysis for pesticide residues contamination as per Rissato et al. (2007), Jimenez et al. (2000) and Blascoc et al. (2004). To reveal overall colony status of *A. dorsata* standard methods as described by Savanurmath et al. (1993) were followed. The collected data was analyzed with the help of SPSS (ver.12.0, Chicago, Inc. USA).

RESULTS AND DISCUSSION

Occurrence, abundance and combs aggregates of *A. dorsata* normal colonies are predicted in Table 2. *A. dorsata* normal colonies were recorded highest (1,560) in Mysore district followed by Chamarajanagar and Kodagu districts respectively 544 and 303 colonies (Table 2). Accordingly, the normal colony density was more (3.64)

Table 1. Physiographic and meteorological details of different districts of southern Karnataka.

S/N	Districts	Longitude	Latitude	Elevation in ft (Height in above msl)	Temp (°C) (Min - Max)	RH (%) (Min - Max)	Average rainfall (in mm)
1	Chamarajanagar	11°55'27.22'' N	76° 56' 18.10''E	2369	16.4 - 34C	21 - 85	731.80
2	Kodagu	12° 20' 14.98'' N	75° 48' 24.87'' E	3027	14.2 - 28.6	68 - 94.5	2800
3	Mysore	12°18'12.72''N	76°38' 46.00'' E	2465	11 - 38	30 - 70	785
Range		11°55′27.22′′ - 12°20′14.98′ N	75°48' 24.87'- 76° 56' 18.10''E	2369 - 3027	11 - 38	21 - 94.5	731.8 - 2800
Average		11.7°31'18.31′N	75.7° 47.3' 29.66'' E	2620.3	13.9 - 33.5	39.7 - 83.2	1202.3

Source: Karnataka State Gazetteer, Bangalore and India Meteorological Station, Bangalore.

Table 2. Occurrence, abundance, aggregates, comb morphometrics and hive products of *Apis dorsata.*

S/N	Asian giant honeybee, *A. dorsata*										
	Distribution of colonies in / at				**Individual colony**						**Colony aggregates**
	District	**No.**	**Season**	**No.**	**Habitat**	**No.**	**Habitat**	**Density**	**Abundance**	**Frequency**	
1	CN	544	R	807	T	1646	T	1.10	4.94	16.58	D:1.57
2	K	303	W	839	RC	181	RC	0.45	4.47	8.06	A:3.19
3	M	1560	S	761	HBS	580	HBS	3.64	4.78	71.48	F:134.07
Total		**2407**		**2407**		**2407**		-	-	-	

Comb morphology				**Comb shape**		**Hive products**	
Brood Comb	**Size (cm)**	**Honey Comb**	**Size (cm)**	**Shape**	**%**	**(kg)**	
Cell depth	1.74±0.07	Cell depth	2.03±0.03	'U'	53.2	Multifloral honey	10,831.5
Cell area	2.36±0.29	Cell area	2.70±0.14	'V'	31.3	Beeswax	1,444.2
Horizontal length	38.09±5.78	Horizontal length	15.89±2.70	Cone	6.2		
Vertical length	28.63±2.12	Vertical length	6.13±1.01	Round	4.9		
Comb width	2.33±0.62	Comb width	12.66±0.51	Uneven	2.6		
		Honey storing capacity (ml)	1.03±0.84	Others	1.5		

CN = Chamarajanagar; K = Kodagu; M = mysore; R = rainy; W = winter; S = summer; T = trees; RC = rock cliff; HBS = human built structures.

in Mysore district while in Chamarajanagar district the colony density was 1.10, whereas the Kodagu district has scored only 0.45 colony densities (Table 2). Similarly, the abundance and percent frequency of colony establishment was varied considerably among these districts (Table 2).

Mysore district experiences moderate climate and floral source due to good water source available at many cultivable lands along with tall ramified trees for nesting. While Chamarajanagar district experiences dry climate, water ways are scanty and accordingly floral source was not good. However, Kodagu district possess good forest coverage with congenial climate and many streams, canals and rivers provide good water source for the luxuriant growth of diversified flowering plants during major part of the year. Despite all these congenial conditions, tall and

Table 3. Nest host tree species and source of flora to *A. dorsata.*

S/N	District	Nest host tree species	Nesting		District	Floral source*					
			Habitat	Elevation		Plant families	Species	Plant types (%)		Forage source from (%)*	
1	Chamarajanagar	08	Trees	5-80 ft	Chamarajanagar	36	70	Herbs	32.0	Ornamental plants	31.0
2	Kodagu	10	Rock cliff	10-30 mt	Kodagu	91	249	Shrubs	26.0	Vegetables	15.0
3	Mysore	17	HBS	8-75 ft	Mysore	96	368	Trees	36.0	Fruit yielding plants	20.0
Total nest host tree species		**20**						Others	6.0	Timber yielding plants	16.0
Total families		**12**	-		**Total**	**223**	**687**	**Total**	**100.0**	Weeds	18.0
										Total	**100.0**

*Floral source: Continuous with little variation between different districts of southern Karnataka; HBS = Human built structures.

long branched tree limbs and rock cliffs are not ideal for nesting due to thickly covered epiphytic vegetation during most of the seasons. Perhaps, these features might have not encouraged *A. dorsata* swarms to establish more colonies at Chamarajanagar and Kodagu districts.

In general, winter scored highest (839) colonies followed by rainy (807) and summer (761) seasons. During winter, the climate is characterized by moderate temperature and humidity with fair floral source at many cultivable lands in southern Karnataka. However, during rainy and summer seasons, the temperature and relative humidity varied considerably along with variable rainfall and resulted with uneven distribution of foraging source. Perhaps during these seasons, *A. dorsata* might have undergone migration to some other places in search of suitable nest sites and forage. Hence, colonies were less during rainy and summer seasons. Our observations are in conformity with the observations of Dyer and Seeley (1994), Thapa et al. (2000) and Shrestha et al. (2002). *A. dorsata* established its colonies on various objects such as on the eaves of trees (1646) followed by HBS (580) and on rock cliffs (181) during different seasons. Altogether, 2,407 normal colonies were recorded at various habitats (Table 2). Further, the colony aggregates per 5^2 m area was three to six combs with an average aggregate density 1.57, aggregates abundance 3.19 and the frequency of aggregations 134.07 found at different elevations (Table 3) respectively on tall tree limbs, high rock cliffs and certain HBS at Chamarajanagar, Kodagu and Mysore districts (Tables 2 and 3).

Solitary nests (only one or rarely more than two colonies on different branches of a bee tree) and colony aggregations (3 to 15 nests on different branches of a single bee tree) are common on many tall trees with broad limbs and giant rock cliffs amidst dry and wet deciduous forest vegetation, scattered tall trees at cultivable lands and on certain multistoried buildings (5 to 45 colonies on a single HBS) in southern Karnataka. Similar type of reports was made by Sahebzadeh et al. (2012) at Malaysia. However, data on solitary nests, colony aggregations and their abundance are beyond the scope of this paper and such observations along with the aggregation structure and their elevation at various bee trees and HBS in southern Karnataka will be published elsewhere.

Further, the brood, honey comb size and shape of colony indicated considerable variations. In brood chamber, the hexagonal shaped cell had 1.74 ± 0.07 cm depth with 2.36 ± 0.29 cm area. Moreover, the horizontal and vertical length of brood comb was 38.09 ± 5.78 and 28.63 ± 2.12 with 2.33 ± 0.62 comb width. However, honey comb cells measured highest depth 2.03 ± 0.03 cm and 2.70 ± 0.14 cm area with 1.03 ± 0.84 ml honey storing capacity. But, the horizontal and vertical length of honey comb was less compared to brood comb. As brood part of the comb is meant for developing young ones, the width is normal when compared to honey storing area .

The comb width was very high (14.66 ± 0.51 cm) accordingly at honey storing part of comb. There were five comb shapes namely ‘U’, ‘V’, ‘Cone’, ‘Round’ and ‘Uneven’ recorded commonly at various habitats. Among them ‘U’ shaped comb was most predominant (53.2%) and hence considered as typical shape to assess the size and honey storing capacities. Results of such observations are depicted in Table 2.

Data from the Table 2 clearly demonstrated that, 10,831.5 kg multifloral honey and 1,444.2 kg of beeswax are produced from *A. dorsata* colonies per year (that is, three to four months of flowering during Kharif and Rabi seasons) indicated the hive products potential (that is, on an average honey yield and beeswax production respectively 4.5 and 0.6 kg per colony) in southern Karnataka. About 20 different tree species belong to twelve

Table 4. *A. dorsata* multifloral honey quality, contamination and harvest.

Multifloral honey quality and contamination				**Multifloral honey**					
Physico-biochemical characters		**Residual pesticides**		**Hunter's education level (%)**		**Hunting by (%)**		**Harvesting (%)**	
pH	3.68 ± 0.1	Organochlorine pesticides		Below primary	12.6	Locals	33.3	Traditional	66.5
Specific gravity (g/cm^2)	1.350 ± 0.02	Organophosphate pesticides		Primary	57.8	Jenu Kurubas	67.7	Improved	33.5
Electrical conductivity (µS/cm)	0.631 ± 0.03	Herbicides	BDL	High school	21.1	Total	100.0	Total	100.0
Absorbance (OD at 359 nm)	2.224 ± 0.38	Pyrethroids		College	1.9				
Turbidity (%)	0.398 ± 0.30	Other pesticides		Illiterate	6.6	-			
		-		Total	100.0				
Sugar content (g/100 g)									
Glucose (G)	51.68 ± 0.41								
Fructose (F)	57.36 ± 2.97								
Ratio of G:F	1.126 ± 0.07								
Invert sugar	108.841 ± 3.35								
Total protein content (g/100g)	2.205 ± 0.79								

BDL = Below detection limit.

families were opted by *A. dorsata* to establish solitary nest or single-comb and high aggregates of open nests (Table 3). The nesting elevation ranged from five to 80 feet on tree species, 10 to 30 m at rock cliffs and eight to 75 feet at HBS (Table 3) and showed considerable variation in nesting. The single-comb was recorded at lower elevations and aggregates were found on tree limbs of tall bee trees along the rock cliffs. Consistent with the observations of Sahebzadeh et al. (2012), *A. dorsata* solitary nests and aggregations were recorded on specific trees that were selected often for nesting. Presumably, *A. dorsata* use certain criteria to select any particular site for nesting, that is, safety, bear the weight, size of nest, free from predators and enemies. It shows that single or numerous *A. dorsata* colonies can settle on various sites at different elevations which become suitable nesting niche to sustain the colony structure. The results agree with the explanation given by Sahebzadeh et al. (2012).

Total 687 flowering plants which belong to 223 familes have extended forage interms of nectar and pollen to *A. dorsata* population. Amongst these, trees and herbs contributed respectively 36 and 32% floral source followed by shrubs (26%) and other flora (6%) to *A. dorsata* (Table 3). The existed forage source was further classified into ornamental plants, fruit yielding plants, timber yielding plants, vegetables and weeds, and their percent contribution is depicted in Table 3. Classifying the existing flowering plant source into various types is a common practice to understand the nectar and pollen source to honeybees during different seasons (Basavarajappa et al., 2010). Since, *A. dorsata* is a voracious forager, visited 687 flowering plants to collect nectar and pollen. These plants could bloom with characteristic apicultural values (that is, in terms of nectar, pollen and both nectar and pollen supply) during different seasons and extended continuous floral source to *A. dorsata* at diversified habitats of southern Karnataka. Similar type of observations was reported by Rao (1973), Basavarajappa et al. (2010) at different habitats of Karnataka. The results agree with the explanation given by the aforementioned authors.

A. dorsata honey quality, its contamination and the process of honey harvesting is shown in Table 4. The multifloral honey had 3.68 ± 0.1 pH, 1.35 ± 0.02 g/cm^2 specific gravity, 0.631 ± 0.03 µS/cm electrical conductivity, 2.224 ± 0.38 optical densities with 0.398 ± 0.30% turbidity. The sugar glucose and fructose content was respectively 51.68 ± 0.41 and 57.36 ± 2.97 with a ratio between glucose and fructose 1.126 ± 0.07. Moreover, the invert sugar content was 108.841± 3.35 (Table 4). Further, the total protein content was 2.205 ± 0.79 g/100 g of honey. Since, honey is one of the internationally traded commodities (Nanda et al., 2003) regular analyses of physical and chemical constituents are essential to maintain internationally acceptable quality. In this regard, researchers from different parts of the world regularly analyze the physico-chemical parameters of honey before it is being marketed. Further, Organochlorine, organophosphate, herbicides and pyrethroid pesticide residues analysis in multifloral honey samples indicated below detection limit (BDL) of all these pesticide residues (Table 4). Thus, results clearly indicated that honey from the colonies of *A. dorsata* is appropriate to the quality standards of TSE and CODEX and good for human consumption. Our results agree with the earlier reports of Nanda et al. (2003), and Ouchemoukh et al. (2007).

In southern Karnataka, the Jenu Kurubas (67.7%) and local farmers (33.3%) harvest *A. dorsata* colonies for multifloral honey by employing traditional and improved methods respectively 66.5 and 33.5% (Table 4). The honey hunters are illiterates (6.6%) and not having good education to learn and adopt scientific harvesting methods. This becomes one of the major setbacks for scientific multifloral honey harvest and resulted conventional hunting. During conventional hunting, honey hunters destroy whole colony by using fire torches and burn the hive bees. This caused serious loss to the colony population and increase *A. dorsata* colony decline.

Although, the combs of *A. dorsata* in the wild are free from pesticide residues, various biological agents and man-made activities acted as stressors and enhanced the colony decline. Possible causes stressing on the survival of *A. dorsata* population are depicted in Table 5. The biological agents include predators (11.1%), pests (38.5%) and man-made activities namely pesticide poisoning (1.6%), uprooting of trees (8.2%), trimming of tree limbs (8.4%), cultural practices (8.9%) (Ex. Clearing of weeds by burning, removal of dead tree limbs, fronds etc, in cultivable lands) and conventional honey hunting (10%) have reduced *A. dorsata* colonies. Further, incidences of colony reduction due to biological agents and man-made activities during different seasons are shown in Table 5. Highest (38.7%) colony decline was recorded due to the infestation of pests (Ex. *Galleria mellonella* and *Neocypholaelaps ampullula* followed by predators (11.1%) (Ex. Monkey, Bat, Flying fox, Green bee-eater, Honey buzzard, Drango, Flycatcher, Tree snakes, Garden lizard, Spiders, Wasps etc.), and conventional hunting activities (10%). Uprooting of bee trees, trimming their limbs and cultural practices at rural and urban habitats have caused serious loss (around 8% each) to *A. dorsata* colony. Accordingly, every year *A. dorsata* colonies are declining considerably in southern Karnataka (Table 5).Interestingly, the phoretic mite, *N. ampullula* is first record on *A. dorsata* and kept in Colombia University, USA under the accession numbers OSAL0106881-886 (Kolmpen, 2011, Personal communication). Although, *Neocypholaelaps* species is not a major pest of *A. dorsata*, its frequent occurrence on the body of foraging worker bees has created nuisance in the hive and results in continuous disturbance in the colony. Moreover, they interfere with normal activities and become troublesome to hive bees. This might have altered the working efficiency of forager bees and hive bees, finally encouraged the disintegration inside the colony. Perhaps, it could weaken the colony population and such colonies become prone to other problems. The greater wax moth, *G. mellonella* commonly infests weak colonies and abandoned combs found on the tree limbs, rock cliffs and HBS. However, the pathogenic diseases such as bacterial, viral, protozoan and fungal diseases were not identified during the present investigation. Thus, pathogenic diseases were not problematic to *A. dorsata* population during the present investigation.

A. dorsata cover larger area (ex. 10^2 km) to gather good amount of nectar and pollen to supplement its huge colony population. During its foraging, various flowering plant species which are partly or completely exposed to pesticide sprays during their bloom by farmers were visited. As a result, the nectar and pollen gets contaminated with residues of various pesticides (Bright et al., 1998). During foraging, several hundreds to thousands of forager bees become victims to pesticide poisoning. Moreover, hive bees along with developing brood also become victim to pesticide poisoning. Ultimately this could cause colony decline Bright et al., (1998).

Caron (1978), Seeley et al. (1982), Jadczak (1986), Novogrodzki (1990), Abrol (2003), Kastberger and Sharma (2000), Thapa et al. (2000), Thapa and Wongsiri (2003) and Nagaraja and Rajagopal (2011) have reported the vertebrates predation on honeybee colonies. The monkey (*Macaca* sp.), drongo (*Dicrurus* sp.), bee-eater (*Merops* and *Nyctyornis* sp.), common crow (*Corvus* sp.), oriental honey buzzard (*Pernis* sp.), rats, honey badgers, foxes, lizards and toads feed on honey, brood, pollen and hive bees. Mammals are major enemies of honeybee colonies (Jadczak, 1986). Species of bears are commonly known as mammalian predators to honeybee colonies. They usually dismantle the hives to feed on honey, pollen, brood and adult bees (Jadczak, 1986). They tear the hives into small pieces and carry off honey comb to escape from mass stinging of bees. They also knock down the colonies of *A. dorsata*. Thus, bears menace is more common during honey flow seasons. Many primates eat honey and brood from the beehive. *Macaca* sp. has been reported to damage brood of A. *florea* (Seeley et al., 1982). The monkeys remove adult bees from the comb and feed on honey and brood and it is very common in south India. The monkeys in troop jump on to the beehive open the top cover and shake it for the bees to fly away. Later they carry away with super and brood combs (Nagaraja and Rajgopal, 2011). *Nyctyornis* species creates nuisance at the hive by making a quick fly fast and disturb *A. dorsata* colonies (Kastberger and Sharma, 2000). For *Merops orientalis,* honeybees form a considerable part of its diet. It captures individual bees and rarely attacks *A. dorsata* hive by

Table 5. Possible causes stressing on the survival of *A. dorsata* population in southern Karnataka.

Possible causes					Incidence				Population decline		
Biological		Man-made		Stressing agents	Season				Year	%	Reference
Agents	%	Activities	%		Rainy	Winter	Summer	Mean			
Predators	11.1	Pesticide poisoning	1.6	Predators	8.8	11.5	13.0	11.1	2006-07	4.0	Basavarajappa et al., 2010
Pests	38.7	Uprooting of trees	8.2	Pests	32.1	25.0	59.1	38.7	2007-08	10.0	Present work
Pathogens	-	Trimming tree limbs	8.4	Pathogens	-	-	-	-	2008-09	6.3	
Mean	24.9	Cultural practices	8.9	Pesticide poisoning	8.3	13.2	11.8	7.1	2009-10	8.0	
		Conventional honey hunting	10.0	Uprooting of trees	11.6	10.5	2.6	8.2	2010-11	9.3	
		Others	6.5	Trimming tree limbs	11.9	11.3	2.0	8.4			
		Mean	7.2	Cultural practices	2.8	11.7	2.1	8.8	On an average 1.3 to 1.7% decline of *A. dorsata* population recorded every year		
				Conventional honey hunting	14.3	7.0	8.7	10.0			
		-		Others	9.6	3.9	6.0	6.5			
				Mean	12.2	10.5	11.7	6.7			

passing close to the colonies and feed on individuals that pursue them to a perch (Kastberger and Sharma, 2000). Moreover, flocks of *M. orientalis* were reported to launch coordinated attacks at *A. dorsata* nests at low ambient temperatures when the bees flying performance is impaired (Thapa et al., 2000). Similarly, *Dicrurus* species create nuisance to the hive bees (Nagaraja and Rajagopal, 2011). It is commonly seen at the vicinity of *A. dorsata* colonies and at various apiaries in Karnataka (Nagaraja and Rajagopal, 2011). Further, *Corvus splendens* also troublesome to honeybee colonies, its menace was recorded at different parts of India (Nagaraja and Rajagopal, 2011). *Pernis ptilorhycus* generally hunt *A. dorsata* colonies to collect brood and honey (Thapa and Wongsiri, 2003). In this way all these predators becomes troublesome to hive bees and their brood and stored hive products. Such troublesome activities perhaps weaken the colony gradually and finally initiate the process of colony desertification.

However, in the present investigation certain mammals (ex. Monkey, Bat and Flying fox), birds (ex. Green bee-eater, Honey buzzard and Drango) reptiles (ex. Tree snakes, Garden lizard), arachnids (ex. Spiders) and insects (Predatory wasp, *Vespa cincta*) have directly or indirectly interfered with the strong and weak colonies, collected the developing brood, honey, pollen, hive bees and individual worker bees. All these activities affected the colony integrity and altered the colony strength and influence the process of colony desertification that finally leads to colony abandonment. Thus, the observations are in conformity with the earlier reports of Van Lawick-Goodall (1968), Caron (1978), Seeley et al. (1982), Jadczak (1986), Novogrodzki (1990), Abrol and Kakroo (2000), Kastberger and Sharma (2000), Thapa et al. (2000), Thapa and Wongsiri (2003), Nagaraja and Rajagopal (2011).

Furthermore, other man-made activities namely uprooting of nesting trees, trimming of tree limbs, cultural practices and conventional honey hunting at cultivable lands, bee trees or at nest sites perhaps developed the nuisance to hive bees in *A. dorsata* colonies. This might have gradually initiated the colony desertification and finally end up with colony abandonment and that results in decline. However, the intensity of all these activities varied considerably during dif-ferent seasons and accordingly *A. dorsata* colony decline has been recorded during different years (Table 5). Highest (10%) *A. dorsata* colony was recorded during 2007-2008 followed by 9.3% during 2010-2011. However, the percent decline was less that is, 4.0, 6.3 and 8 respectively during 2006-2007, 2008-2009 and 2009-2010 (Table 5).During 2007 and 2008, untold incidents such as pesticide poisoning, uprooting and trimming of trees accompanied with cultural practices and conventional honey hunting practices were enor-mous at various habitats of southern Karnataka. Perhaps, this could be one of the reasons for highest decline of *A. dorsata* colonies during

2007-2008. However, on an average 1.3 to 1.7% *A. dorsata* colonies depleting every year at various habitats of southern Karnataka. Thus, it clearly demonstrates that, *A.dorsata* colonies are declining under natural conditions due to various biological agents and unwanted man-made activities at the vicinity of nesting habitats. Hence, colony status of *A. dorsata* is at brink in Southern Karnataka.

SUMMARY AND CONCLUSION

A. dorsata is distributed at various ecosystems by establishing its big sized colonies. *A. dorsata* selected more than twenty tree species, several rock cliffs at hilly areas and HBS for nesting at southern Karnataka. Total 2,407 normal colonies and 2,028 abandoned combs were recorded during different seasons. The solitary nests or single comb and colony aggregates per 5^2 m area was three to six combs with an average aggregate density 1.57, aggregates abundance 3.19 and the frequency of aggregations 134.07 found at different elevations on tall tree limbs, high rock cliffs and at certain HBS in southern Karnataka. The hive products potential per *A. dorsata* colony was 4.5 kg honey and 0.6 kg beeswax and around 10,831.5 kg multifloral honey and 1,444.2 kg beeswax per year from the existing *A. dorsata* colonies. Multifloral honey contained a mixture of sugars namely glucose, fructose, which was in good ratio with required amount of total invert sugars. The total protein content was good with acidic pH.

The specific gravity and the electrical conductivity were in good range. Moreover, the honey had little turbidity with moderate absorbance. Interestingly, none of the honey samples were contaminated with detectable pesticides limit. Thus, the combs of *A. dorsata* in the wild were free from pesticide residues in southern Karnataka. The parasitic/or phoretic mite, *N. ampullula,* greater wax moth, *G. mellonella* infested the weak normal colonies and abandoned combs. Altogether, the developing brood, honey, worker bees and hive bees were predated by certain animals, which altered the live colony integrity and influenced the colony desertification. The pathogenic diseases were not much problematic to *A. dorsata* population and did not show any incidences of pathogenic diseases. Besides parasites and predators impact, the intensive man-made activities at different habitats have encouraged the colony decline 1.3 to 1.7% every year. This is how, *A. dorsata* population decreasing considerably. Although information on colony status could help reveal the current trends of *A. dorsata* population, in depth molecular approaches are essential to support the present work. However, it is beyond the scope of this paper and results of such studies shall be published elsewhere. Thus, multifaceted approach in the present investigations could help assess the colony status of *A. dorsata,* which is at threatened state and require conservation in its natural abode.

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