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Behavior of blue banded bees, *Amegilla zonata* L. (Apidae: Hymenoptera)

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Abstract

Male bees and female bees are floral visitors and collect floral rewards. Flight activity of female bee begins just before dawn and continues upto dusk. They collect nectar or pollen from 21 crop plants and 12 weeds. Among the various plant families Fabaceae, Solanaceae and Cucurbitaceae are predominantly preferred and foraged. They are attracted mainly to yellow coloured flowers. Female bee guards the nest by remaining within the nest shaft. Most of the sleeping clusters are intraspecific and male biased and rarely sex mixed. Males take rest during dusk either singly or in a cluster on the terminal end of the dried weeds by grasping the stem firmly with their mandibles and fall asleep. Interspecific sleeping clusters are also found occasionally which involved cuckoo bees (*Thyreus* sp.) and leaf cutter bees (*Megachile* sp.). When both the sexes are brought together and confined in enclosures forced mating can occur.

Keywords: Blue banded bees, *Amegilla*, Behavior, India

1. Introduction

Blue banded bees are commonly seen on flowers. These bees have a greater role in crop pollination. They extend excellent ecological service as a crop pollinator. They are adequate pollinators of eggplant, capsicum and tomatoes. Many Solanaceous plants depend on this mode of pollination for productive yields^[4]. Blue banded bees are potential pollinators of greenhouse tomatoes^[3]. Tomato yield was increased in greenhouses due to the pollination activity of *Amegilla chlorocyanea*^[6]. The huge, plumpy, juicy grubs of Dawson's bees (*Amegilla dawsoni*) were used as a choice food for the local aborigines of Australia. The male bees wait at the nest entrance for the virgin female bee to come out. They can detect the presence of female bee even while she is inside the tunnel. The male bees fight with each other using their mandibles and winning bee alone can mate with female bee^[8]. Mating occurs in nesting areas and mainly at the forage sites. The female bee normally mates only once and mating lasts about seven minutes in *Amegilla dawsoni*^[12]. The female, mounted by the successful male, ran over the ground for some meters until the pair was hidden beneath some small plants and there coupling lasted for about two minutes^[8]. Sleeping aggregations have been observed in various solitary bees^[10]. Such aggregations consist of usually conspecific males rarely with few females gathering on plant stems. In most of the Hymenopteran species males have been observed spending the night on flowers or leaves but most of the females spend the night in burrows or nest structures. Normally they do not sting. They are not aggressive. Even if they sting it will be just only like a pin prick. The bees swarm about intruders at nest aggregations but do not attack them. Hence, they do not pose any threat to the people.

Research studies on behavior and floral resources of blue banded bees are inadequate. Keeping in mind their importance in pollination and behavior. The present research was taken up to study their behavior.

2. Materials and methods

2.1. Floral resources

Documentation on floral resources for blue banded bees were taken up in the college campus and also in the nearby fields of farmers growing vegetables during the study period. The pollen foragers and nectar foragers were differentiated based on their foraging behavior while collecting different floral rewards namely pollen and nectar. The nectar foragers stretched out their lapping tongue and sipped the nectar from the nectaries and as a result of feeding nectar the gaster became swollen.

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Such plants offering nectar to these bees were classified as nectar resources. The pollen foragers visited many flowers within a short time and loaded the collected pollen in their scopae. Those plants offering pollen to bees are classified as pollen resources. The plants which provided both nectar and pollen were categorized as sources of both floral rewards *viz.*, pollen and nectar. The colours of the floral resources were also recorded along with their names and family. The floral resources were categorized both crop wise and their family wise. Certain cursory observations on foraging behavior like peak period of foraging, pattern of flower visitation and pollination were also taken wherever possible.

2.2. Mating behaviour

Nesting sites and foraging sites were observed every now and then to study the actual mating behavior. An attempt was also made to study the mating behavior in captivity. The male bee was collected from foraging site. A fresh female bee was collected from the matured brood cell kept inside a container after emergence. Both male and female bees were confined together inside a polythene bag. To induce the pair to make genital contact, the bag was jerked a few times to bring both the sexes together for forced mating. Both male and female behavior was observed while mating.

2.3. Female and Male behavior

Female and male behaviors were observed and field observations on gregarious sleeping in blue banded bees were taken during April 2016. The plants providing shelter for sleeping were found out. *In situ* observations were taken pertaining to cluster formation. Assembling time, departing time, behavior of bees in the cluster and sexes constituting the aggregation were recorded. Behavior modifications induced in bees due to the removal of sheltering plants and rains were also observed.

3. Results

3.1. Floral resources

During the study 21 crop flora (Table 1) and 12 weed flora (Table 2) were documented as floral resources for blue banded bees. They collected nectar or pollen or both. Guava, yellow bell, Indian mallow (Fig 1) and Senna offered both nectar and pollen for the bees. The bees are very much attracted to Solanaceous and Cucurbitaceous vegetable crops. These bees clinged to the anther column of eggplant and vibrated the same to release the pollen grains through the poricidal anther on their back. Thus they effected buzz pollination in the above crops. Similar foraging behavior was also observed on tomato. Cucurbit crops (Fig 2) like bitter gourd, ash gourd and cucumber with attractive yellow coloured flowers lured the bees in large number and offered nectar for the bees. Similarly, yellow bell attracted more bees and offered nectar as floral reward. In Malabar cat mint (*Anisomeles malabarica*) (Fig 3) intense bee activity was observed from 7.00 am to 9.00 am. The bee visitation on this crop was more on days following the rains. Likewise in both sunhemp and daincha intense bee activity was observed which also had yellow coloured flowers. Among the weed flora cat whiskers, *Cleome gynandra* a widely prevalent weed was found to be the best ground flora which offered mainly pollen. This bee was found to collect nectar from both floral and extra floral nectaries in *Abuliton indicum*. Similarly *Lantana camara* with its multi-coloured flowers was equally attractive for the bees. Among the various plant families Fabaceae,

Solanaceae, Cucurbitaceae, Compositae (Fig 4) and Bignoniaceae appeared to be predominantly preferred for foraging by these bees.

Both male and female bees were floral visitors. Female bees collected both pollen and nectar while male bees sipped nectar alone from the flowers. They frequently hovered above and around the flowers before landing on them. They flew very fast and quickly visited many flowers per minute. They were often seen darting around the flowers. They commenced their foraging activity around 6.00 am and stopped foraging at 6.30 pm and their flight activity continued all throughout the day. A single bee visited numerous flowers during each foraging trip. Pollen foraging was taken up by the mother bee after brood cell construction. Bees after pollen foraging returned to the nest with their scopae on hind legs loaded with pollen.

3.2. Mating behavior

During the study period we could not observe mating in blue banded bees at foraging site, nesting site and sleeping site. Under forced mating conditions male bee widely stretched out its middle and hind legs prior to mating. The female bee approached the male bee from below and established sexual contact and mated with male. During copulation the female bee was lying on its back and male bee was found above.

3.3. Female and Male behaviour

The female bee also assumed the role of defending the nest against intruders. During guarding the head alone was visible and the body virtually blocked the nest entrance thereby preventing the entry of enemies. Female bees in a nest congregation exhibited an apparent gregarious defending towards intruders at the nest site. They hovered around the intruder. They also stung the intruder by using their retractile stings when the bees were roughly handled near nesting sites, resting sites and foraging sites. Duration of pain inflicted by stinging persisted for one to two hours. Sting autotomy did not occur after stinging. The sting was exerted out and retracted rapidly when the gaster was gently hold. Due to their fast flying behavior foragers could escape even if they were trapped in spider web. However, young bees were trapped in spider web. Female bees took rest only in well shaded places and did not prefer to take rest at sites exposed to direct sunlight. They took a rest on plants during day time by remaining on the leaf lamina. The bees were found to take rest on *Echinochloa colona*, *Vicoa* sp), *Achyranthes aspera*, *Crotalaria juncea*, *Sesbania aculeata*, *Acacia nilotica* and *Tecoma* sp. During resting sometimes the bees moved the gaster up and down.

The sleeping sites were always found nearer to food plants. Sleep cluster formation started (Fig 11) just before sunset (5.49 pm to 6.19 pm). Cluster departure occurred just before sunrise (Fig 10) between (5.45 to 6.12 am). In general sleeping clusters were formed with many males and few females. Sometimes they also formed exclusively male biased or female biased clusters. Each cluster was made up of 2 to 25 bees and one to eight clusters were formed per plant. Inter distance between clustering sites ranged from 1 to 15 m. Male bees regularly visited the sleeping sites where as the female bees did not maintain regularity in visiting the sleeping sites. Most of the sleeping clusters observed during the study were male biased. Bees hovered in groups in the air for a while prior to landing. They exhibited both dorso-ventral and telescopic gaster movements after landing on the plant. The

first individual freely landed on the substratum. Other bees which landed subsequently hit against the bee landed earlier. After landing the bees fluttered their wings and also wiped their wings with their hind legs.

Males took a rest during dusk either singly or in a cluster on the terminal end of the dried weeds like *Chloris barbata*, *Vicoa* sp and *A. aspera* (Fig 5). On thin stemmed weeds viz., *C. barbata* and *A. aspera* the bee cluster caused the slender stem to bow down due to the combined weight of bees constituting the sleeping cluster. They grasped the stem firmly with their mandibles (Fig 6) and tucked up their legs beneath them and fell fast asleep. During resting the legs were held close to the body. Isolated roosting of females (Fig 7) on *C. barbata* has been occasionally observed two meters away from the male congregation.

The bees which formed several clusters on *Vicoa* sp gathered together daily on the same plant during the entire month of April which fluctuated daily. Usually the sleeping clusters of these bees had both the sexes. But in one location the clusters had also a few cuckoo bees (*Thyreus* sp) and leaf cutter bees (*Megachile* sp) (Fig 8). Sex mixed aggregations lasted for 45 days during April 2016 (Fig 9). Removal of weeds forced the bees to form clusters on the nearby plants.

4. Discussion

Unlike honey bees both male and female bees are attracted to the floral sources. The male bees mainly visited flowers for collecting nectar. Foraging was essential for the male bees also for their survival and sustenance of life until they performed the duty of impregnating a female bee. Flora with yellow coloured flowers attracted more bees since bees showed more preference for yellow colour (Fig 12). There is a good potential to use these native bees for planned pollination of tomato and eggplant [7]. Females were observed to forage on flowers of only four plant genera *Cassia* (Caesalpiniaceae), *Eremophila* (Myoporaceae), *Solanum* (Solanaceae) and *Trichodesma* (Boraginaceae) despite the availability of a much wider selection of pollen and nectar sources at some localities. The females did not enter the tubular corollas and were able to extract nectar by inserting their long proboscis [8] and these are similar to our present findings.

Many bee species are floral generalists ("polylectic"), taking pollen from many taxa of flowers, a necessity for the long-lived colonies of social bees. Foraging individuals often will display floral constancy, selectively visiting sequences of conspecific flowers on a given foraging trip, despite the availability of alternatives [5]. Normally they do not sting. Even if they sting it will be just only like a pin prick. The bees swarm about intruders at nesting aggregations but do not attack them. The defensive behavior is rare among solitary bees, even those which nest in aggregations, but is common and often violently expressed in social aculeate Hymenoptera were similar to those observations made by [13]. Sleeping clusters are usually formed in dark places for spending the night which is essential for their survival. These clusters are usually intraspecific and rarely interspecific. Interspecific clusters observed in our studies had leaf cutter bee (*Megachile* sp) and cuckoo bee (*Thyreus* sp) apart from the *Amegilla* sp. The sleeping clusters are either sex biased or sex mixed. They consisted of only males, only females and a sex mixed aggregation similar observations were also reported [14] in *Amegilla florea urens*. In general males dominated the sleeping clusters. Sleeping clusters formed by stingless bees

(*Tetragonula iridipennis*) contained only males [11]. Female biased congregations were usually rare because they usually remained within the nest and took rest and defended the colony. Regular visitation to sleeping sites led to the formation of female biased or sex mixed aggregations. The bees forming the sleeping cluster exhibited certain stereotypic behavior before during and after landing at the site. They performed wagging their gaster up and down. Though the population of bees fluctuated over a period these bees showed site fidelity and formed congregations at the same site every day were agreed with [2,9]. They Clinged to the plant with their jaws alone, they did pushups on their powerful jaws. The bees in sleeping clusters were negatively phototactic. Hence, they were not usually attracted to light sources. Formation of sleeping clusters helps in getting protection against natural enemies and adverse weather conditions.

During our study we could not observe the natural mating process. Hence, we tried to induce mating in captivity with partial success. However, we could gather some understanding about the mating behavior of *Amegilla* sp. Two types of males namely flower patrolling males and territorial males were reported in *Amegilla paracalva* [1] but in our studies all males were found to be same and male dimorphism was totally absent. Since the chances of pairing is more usually in nesting sites and it can also occurs in foraging sites. The female bee mate with a male bee only once in her life time and mating does not harm the male bee in anyway.

5. Conclusion

The research concluded that male bees and female bees are floral visitors. Flight activity of female bee begins before 6:00 am and continued up to 6:30 pm and bees returning from their foraging trips hover around the nest in circles before landing. Twenty one crop plants and 12 weeds were recorded as pasturage plants providing nectar or pollen or pollen & nectar and honey. *Senna auriculata*, *Psidium guajava*, *Tecoma* sp and *Abuliton indicum* were providing both nectar and pollen to the bees. Among the various plant families Fabaceae, Solanaceae, Cucurbitaceae and Bignoniaceae are predominantly preferred and foraged. The bees are very much attracted to Solanaceous and Cucurbitaceous vegetable crops. Bees are effective in buzz pollinating egg plant crop. Bees are attracted mainly to yellow coloured flowers followed by white and purple flowers. Bee guards the nest by remaining within the nest shaft and bees hover around the intruder at nest congregation site but they do not sting. Bees sting only when provoked or roughly handled at nesting, foraging and sleeping sites. Sting autotomy does not occur after stinging. Most of the sleeping clusters are intraspecific and male dominated, male bees exhibit stereotypic movements during and after the formation of sleeping clusters. Female biased and sex mixed sleeping clusters also occur rarely. Males take rest during dusk either singly or in a cluster on the terminal end of the dried weeds by grasping the stem firmly with their mandibles. Interspecific sleeping clusters are also found occasionally and Interspecific clusters have cuckoo bees (*Thyreus* sp.) and leaf cutter bees (*Megachile* sp.) apart from blue banded bees (*Amegilla* sp.). Sleeping clusters are found on weeds viz., *Achyranthes aspera*, *Vicoa* sp and *Chloris barbata*. Middle and hind legs of male bee were outstretched prior to mating. The female bee approached the male bee from below and established sexual contact and mated with male. During copulation the female bee was lying on its back and male bee was found above.

Table 1: Crop flora utilized as floral resources by blue banded bees (*Amegilla zonata*)

Sl. No	Common name	Botanical name	Family	Flower colour	Floral reward
1	Maize	<i>Zea mays</i> L.	Poaceae	Brown	P
2	Red gram	<i>Cajanus cajan</i> L.	Fabaceae	Brown	N
3	Green gram	<i>Vigna radiata</i> R. Wilczek	Fabaceae	Yellow	N
4	Sesamum	<i>Sesamum indicum</i> L.	Pedaliaceae	White	N
5	Sunflower	<i>Helianthus annuus</i> L.	Compositae	Yellow	N
6	Guava	<i>Psidium guajava</i> L.	Myrtaceae	White	N& P
7	Passion fruit	<i>Passiflora</i> sp L.	Passifloraceae	White	N
8	Egg plant	<i>Solanum melongenum</i> L.	Solanaceae	Purple	P
9	Tomato	<i>Lycopersicon esculentum</i> L.	Solanaceae	Yellow	N
10	Drumstick	<i>Moringa oleifera</i> Lam.	Moringaceae	White	N
11	Pumpkin	<i>Cucurbita moschata</i> L.	Cucurbitaceae	Yellow	N
12	Cucumber	<i>Cucumis sativus</i> L.	Cucurbitaceae	Yellow	N
13	Bitter gourd	<i>Momordica charantia</i> L.	Cucurbitaceae	Yellow	N
14	Senna	<i>Senna auriculata</i> L.	Fabaceae	Yellow	N& P
15	Malabar Catmint	<i>Anisomeles malabarica</i> R. Brown	Lamiaceae	Purple	N
16	Sunhemp	<i>Crotalaria juncea</i> L.	Fabaceae	Yellow	N
17	Daincha	<i>Sesbania auriculata</i> W. Wight	Fabaceae	Yellow	N
18	Yellow bell	<i>Tecoma gaudichaudi</i> Juss	Bignoniaceae	Yellow	N & P
19	Yellow bell	<i>Tecoma stans</i> Juss	Bignoniaceae	Yellow	N & P
20	Lilly	<i>Nymphaea odorata</i> L.	Liliaceae	White	N
21	White Alder	<i>Turnera subulata</i> Sm.	Passifloraceae	White	P

P-Pollen **N-Nectar** **P & N-Pollen & Nectar**

Table 2: Weed flora utilized as floral resources by blue banded bees (*Amegilla zonata*)

Sl. No	Common name	Botanical name	Family	Flower Colour	Floral reward
1	Indian Borage	<i>Trichodesma indicum</i> R. Brown	Boraginaceae	White	N
2	Big sage	<i>Lantana camara</i> L.	Verbanaceae	Purple	N
3	Coat buttons	<i>Tridax procumbens</i> L.	Asteraceae	Yellow	N
4	Purple bush bean	<i>Macroptilium atropurpureum</i> Urb	Fabaceae	Purple brown	N
5	Indian mallow	<i>Abutilon indicum</i> L.	Malvaceae	Yellow	N & P
6	Benghal dayflower	<i>Commelina</i> sp L.	Commelinaceae	Purple	N
7	Jimson weed	<i>Datura stramonium</i> L.	Solanaceae	White	N
8	Fever root	<i>Ruellia tuberosa</i> L.	Acanthaceae	Purple	N
9	Wild mustard	<i>Cleome viscosa</i> L.	Capparidaceae	Yellow	N
10	'Thumbai'	<i>Leucas aspera</i> L.	Lamiaceae	White	N
11	Cats whiskers	<i>Cleome gynandra</i> L.	Cleomaceae	White	P
12	Goats-head	<i>Tribulus terrestris</i> L.	Zygophyllaceae	Yellow	N

P-Pollen **N-Nectar** **P & N-Pollen & Nectar**

**Fig 1:** *Amegilla zonata* foraging on Indian mallow**Fig 2:** *Amegilla zonata* foraging on cucumber**Fig 3:** *Amegilla zonata* foraging on malabar Cat mint**Fig 4:** *Amegilla zonata* foraging on sunflower



Fig 5: Roosting on *Achyranthus aspera*



Fig 6: Clinging to twig with mandibles



Fig 7: Isolated, female biased clustering of *Amegilla zonata*



Fig 8: Interspecific sleeping cluster

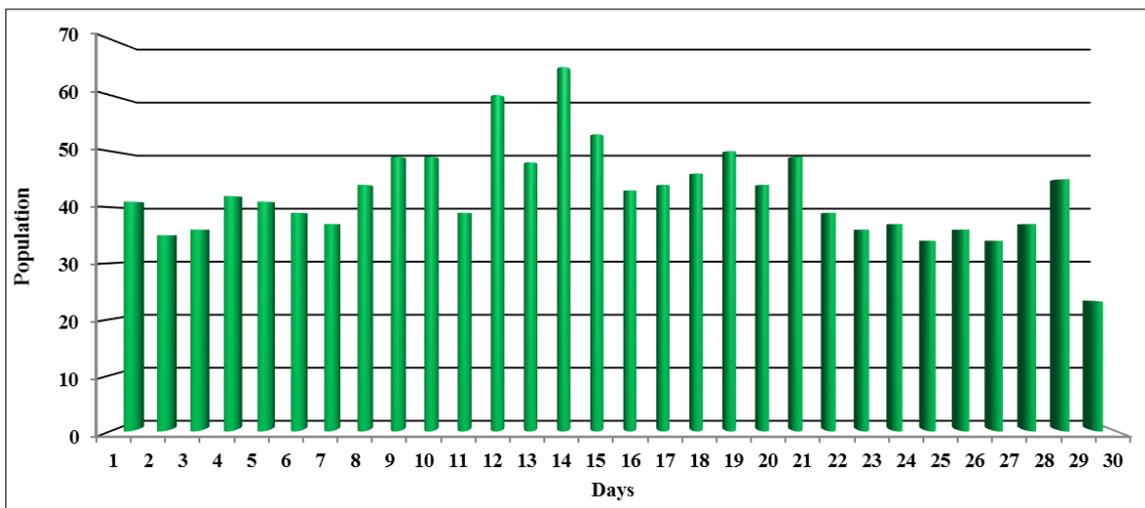


Fig 9: Population density of *Amegilla zonata* in sleeping clusters

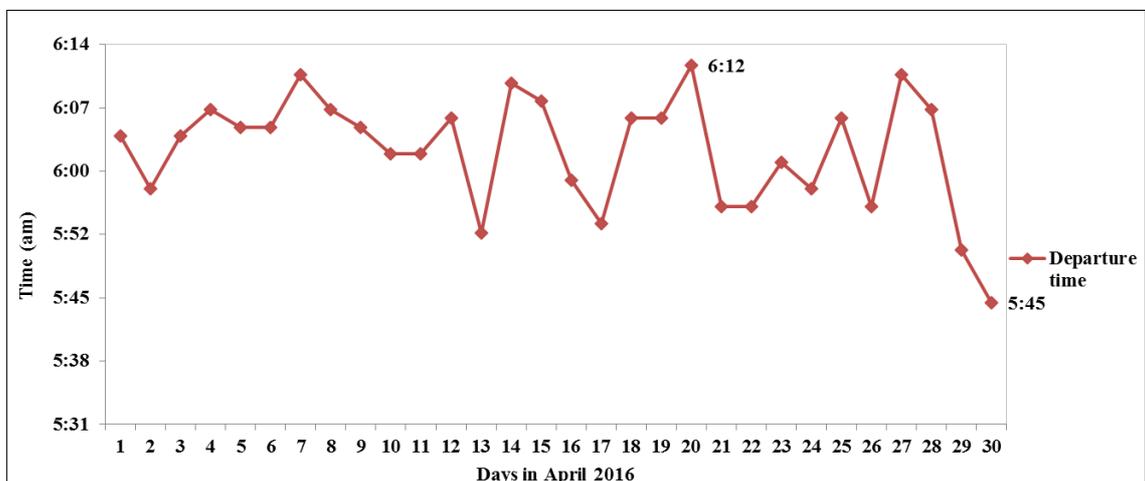


Fig 10: Time of dissolution of sleeping clusters in *Amegilla zonata*

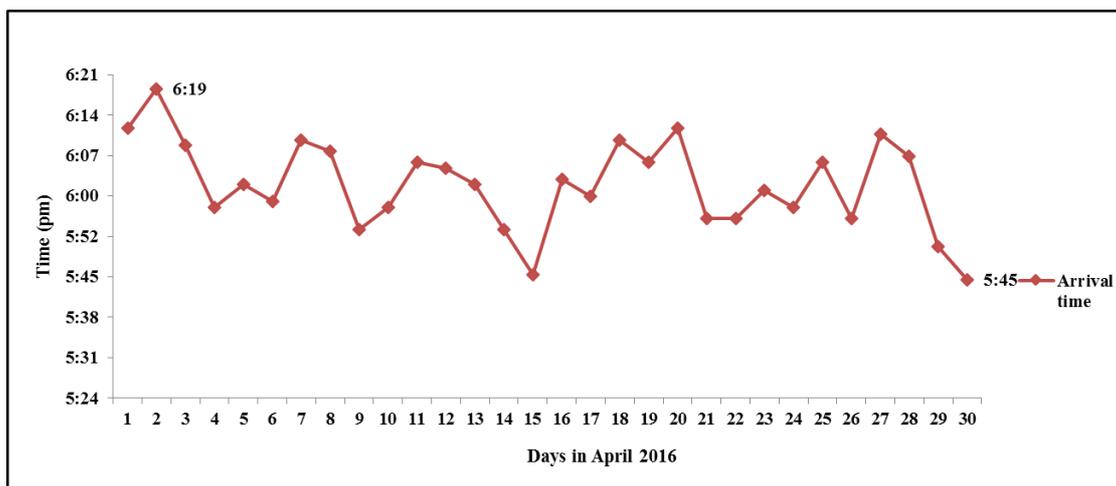


Fig 11: Time of formation of sleeping clusters in *Amegilla zonata*

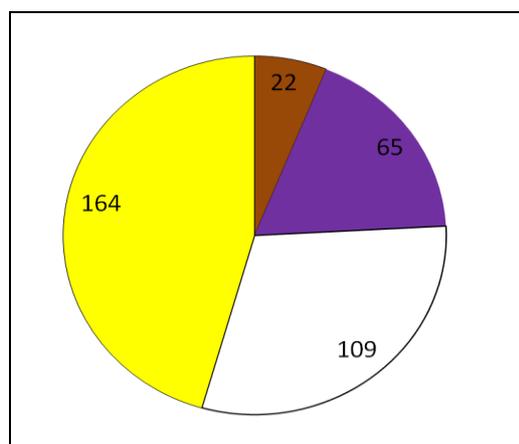


Fig 12: Host floral colours prefer listed (% proposition) by blue banded bees under study

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