



E-ISSN: 2320-7078

P-ISSN: 2349-6800

JEZS 2018; 6(5): 2346-2350

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Received: 19-07-2018

Accepted: 20-08-2018

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Morphometric studies on blue banded bees, *Amegilla zonata* L. (Apidae: Hymenoptera)

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Abstract

The paper describes and illustrates the most common blue banded bee occurring in India is *Amegilla zonata* (Linnaeus). Both the sexes can be easily differentiated easily based on size, clypeal markings, compound eyes, number of flagellomeres, mandibles and bluish bands on metasoma. These bees are characterized by long glossa, short paraglossa, six segmented maxillary palp, hind leg with scopa and legs lacking arolia. In male bee the gonostylus is reduced to a blister.

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

1. Introduction

Blue banded bees are solitary bees which are characterized by their glittering blue color bands on their abdomen. Blue banded bees are Anthophorine bees. An Anthophorine bee was first described by Linnaeus in 1758 as *Apis retusa*. Latreille described first Anthophorine genus in 1802 and in 1803 he proposed the name *Anthophora*. Fabricius named a genus as *Megilla* in 1805. The name *Megilla* is now regarded as a junior synonym of *Anthophora* (Michener, 1974) [5], Anthophorine bees are now grouped under the family Apidae, sub family Apinae and tribe Anthophorini (Brooks, 1988; Michener, 2000) [2, 6]. The two important genera of the tribe Anthophorini are *Anthophora* and *Amegilla* which are easily distinguished based on the presence or absence of arolium. The male genitalia of different Anthophorine bees vary distinctly. They frequently bear metallic blue or green pubescent bands on metasomal terga. They are otherwise called burrowing bees or digger bees because of their fossorial nesting habit. They fly very fast hence they are also called miniature rockets. *Amegilla* is the most important genus which includes blue banded bees. *Amegilla* is a diverse group of bee species distributed in tropical and subtropical regions of the world. Bees of the genus *Amegilla* Friese 1897 (Apidae: Anthophorini) are robust, fast flying, long tongued that have wide distribution in the 'Old World' (Michener, 2007) [7]. The genus *Amegilla* is a diverse group of approximately 255 Anthophorine bee species distributed in and around the world (Engel, 2007) [3]. Recent research has shown that these bees have a strong preference for buzz pollinated flowers, and are adequate pollinators of many crop plants. Blue banded bees are potential pollinators of greenhouse tomatoes (Bell *et al.*, 2006) [1]. Tomato yield was increased in greenhouses due to the pollination activity of *Amegilla chlorocyanea* (Hogerdoorn *et al.*, 2006) [4]. Keeping in mind their importance in agriculture, existing research gaps and uninterrupted availability of these bees throughout the year in Tamil Nadu. The present research was taken up to study the morphometric characters of the most common species of blue banded bees.

2. Materials and Methods

Studies were conducted to find out the blue banded bee fauna of Tamil Nadu during 2015-16. Research efforts were taken to characterize the blue banded bees. Blue banded bees were collected from Tamil Nadu. Insect nets were used for collecting the bees from foraging sites and nesting sites. Polythene bag was used for collecting bees from sleeping clusters during night. Collected insects were killed using a poison bottle where ethyl acetate was used as a killing agent. The specimens were transferred to the butter paper packets with proper labels providing details about host plant, date of collection and locality. The specimens were brought to the laboratory for subsequent processing. The bees were pinned through thorax and preserved in insect boxes with proper labeling. The male bees selected for genitalia were

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cleared with 10 percent KOH in distilled water. Initially by heating for 15 minutes and later soaked overnight before dissection. The genitalia and sclerites viz., S7 and S8 were removed by using a fine forceps and dissection needle. Later permanent mounts were made by following standard

procedures. Morphometry studies were conducted with twenty males and twenty females. Measurements were taken for various morphometric parameters as detailed below (Table 1). All measurements were made with Leica M205A microscope and are expressed in millimeters.

Table 1: Morphometric parameters studied

Sl.no	Parameters	Definition of parameters
1	Body length	Distance between anterior point of vertex and terminal end of gaster
2	Length of head	Distance between anterior and posterior margin of head
3	Width of head	Maximum distance between lateral margins of eyes
4	Length of compound eye	Distance between upper and lower margins of compound eye
5	Width of compound eye	Distance between lateral margins of compound eye
6	Length of scape	Distance between the proximal and distal margin of the scape
7	Length of pedicel	Distance between proximal and distal margin of pedicel
8	Length of F1	Distance between proximal and distal margin of first flagellomere
9	Inter antennal distance	Distance between inner margins of the antennae
10	Antenno-ocellar distance	Distance between antennal margin to lateral ocellus.
11	Upper IOD	Distance between upper margins of compound eye
12	Lower IOD	Distance between mandibular articulations.
13	Length of mandible	Distance between proximal and distal margin of mandible
14	Length of mesosoma	Distance between anterior margin of pronotum and posterior margin of propodeum
15	Width of mesosoma	Distance between points where tegula projected most at the sides
16	Length of forewing and hind wing (Plate 2)	Distance between basal margin of wing to tip of wing
17	Length of 1 st SMC (Plate 2)	Distance between Rs to first submarginal cross vein
18	Length of 2 nd SMC (Plate 2)	Distance between first and second submarginal cross veins
19	Length of 3 rd SMC (Plate 2)	Distance between second and third submarginal cross veins
20	Length of fore tibia	Distance between proximal and distal margin of tibia
21	Length of fore basitarsus	Distance between proximal and distal margin of basitarsus
22	Length of hind tibia	Distance between proximal and distal margin of hind tibia
23	Length of hind basi tarsus	Distance between the proximal and distal margin of hind basitarsus
24	Length of metasoma	Distance between the base and tip of gaster
25	Width of metasoma	Distance between the lateral margins of metasoma, where width is maximum.

IOD-Inter Orbital Distance

F1-Flagellomere one

SMC-Submarginal Cell

The identity of taxa upto tribe, genus, subgenus and species was done by using keys, and also by comparing the description of the species available in literature (Brooks, 1988) [2] and (Michener, 2000) [6]. The metric data of different morphometric characters were compared by using mean and standard deviation. Simple t-test was done to find out the existence of significant difference between morphometric values relating to male and female bee.

3. Results

The present study was taken up to study the species composition, nesting biology, floral resources and behaviour of blue banded bees. The results of the studies are presented below.

3.1 Species composition

The study has revealed the existence of a single dominant blue banded bee species *A. zonata*. The description of male bee (Fig 1) and female bee (Fig 2) along with morphometric are given below.

3.1.1 Description of male

Body length 10.01-12.61 mm, head length 2.51-2.30mm, head width 3.74-4.34mm, compound eye length 1.98-2.93 mm, compound eye width 1.11-1.45 mm, length of scape 0.41-0.75 mm, length of pedicel 0.12-0.26 mm, length of F1 0.28-0.52 mm, inter antennal distance 0.89-1.33 mm, antenno-ocellar distance 0.78-1.11 mm, upper inter orbital distance 1.92-2.35 mm, lower inter orbital distance 1.72-2.08 mm, length of mandible 1.02-1.48 mm, length of mesosoma 2.45-3.55 mm, width of mesosoma 3.04-4.02 mm, length of fore wing 6.29-

8.78 mm, length of hind wing 4.54-6.62 mm, length of first submarginal cell 0.27-0.68 mm, length of second submarginal cell 0.38-0.66 mm, length of third submarginal cell 0.3-0.62 mm, length of fore tibia 1.03-1.77 mm, length of fore basitarsus 1.0-2.42mm, length of hind tibia, 1.86-3.25 mm. length of metasoma 4.1-7.09 mm, width of metasoma 4.17-4.89 mm.

Combined lengths of second and third submarginal cells were greater than length of first submarginal cell. Hind wing with 22 hamuli. Integument of head black except as follows: flagellum brown, except ventral surface of scape yellow, labrum yellow, quadrangulate with silvery hairs, absence of clypeal markings (Fig 3), Flagellum with 11 flagellomeres serrated mandibles with black coloured edge, integument of legs and tegula brown, wing veins dark brown, membrane hyaline, integument of metasomal terga black, sterna black brown, metasomal terga imbricate, Pubescence of head and thorax yellow, white setae on pleura, outer surfaces of leg parts with white setae, presence of tibial spur and arolia absent, setae largely white with faintly iridescent blue on terga, bear 5 metallic blue pubescent bands on the metasomal terga. The male genital capsule consists of a median penis with a pair of lateral penis valves and a pair of well-developed gonocoxite and reduced gonostyli (Fig 5), a gonocoxite is large with blunt apical lobes which are slightly expanded and hairy at apex. The gonostyli are represented as a pair of blisters which are almost as long as wide. The inner surface of the penis valve is slightly convex. The 7th metasomal sternite (S7) is made up of a single sclerite which measures 1.2 mm long (Fig 6). It is laterally expanded, medially flat and basally with thick dense patch of hairs. The 8th metasomal sternite

(S8) is also made up of a single sclerite. It is basally narrow and distally wide with well-defined margin (Fig 7)

3.1.2 Female

Body length 10.9-13.87 mm, head length 2.67-3.57 mm, compound eye length 2.27-3.08 mm, compound eye width 1.04-1.79 mm, length of scape 0.5-0.93 mm, length of pedicel 0.1-0.2 mm, length of F1 0.46-0.82 mm, inter antennal distance 1.05-1.52 mm, antenno-ocellar distance 0.74-1.21 mm, upper inter orbital distance 2.16-2.55 mm, lower inter orbital distance 1.89-2.39 mm, length of mandible 1.17-1.95 mm, length of mesosoma 2.84-4.24 mm, width of mesosoma 3.28-4.49 mm, length of fore wing -7.63-9.72 mm, length of hind wing 5.38-7.01 mm., length of first submarginal cell 0.3-0.7 mm, length of second submarginal cell 0.33-0.65 mm., length of third submarginal cell 0.41-0.7 mm, length of metasoma 4.25-7.62 mm, width of metasoma 4.38-5.81 mm, black colour spots on clypeus (Fig 4), Flagellum with 10 flagellomeres. Hind wing with 22 hamuli. Combined lengths of second and third submarginal cells greater than length of first submarginal cell, bear 4 metallic blue pubescent bands on the metasomal terga, retractile ovipositor.

Morphometric variations between male and female of *A. zonata* are presented in (Table 2). The male and female bee had different morphometry pertaining to 22 characters however four characters (length of pedicel, length of second submarginal cell, length of fore basitarsus, length of hind basitarsus) did not show any significant variation between male and female bee. The morphometric measurements of various body characters were greater in female than that of male. Both length and width of compound eyes were greater in female than in male. Number of flagellomeres was 11 in male and 10 in female. Mandibles were longer (1.46 ± 0.05) in female than in male 1.23 ± 0.03).

4. Discussion

The species of blue banded bees commonly occurring in the campus is found out as *Amegilla zonata* and it belongs to the subgenus *Zonamegilla*. The identity was fixed mainly based on the keys provided by Brooks (1988) [2] and Michener (2000) [6].

Like all true Hymenopterans blue banded bees have membranous wings and both the wings are coupled by hamulate type of wing coupling mechanism. In *A. zonata* 22 hamuli are present on the costal margin of the hind wing which are hooked with the cuticular fold present on the anal margin of forewing during flight. The first abdominal segment is shifted to thorax. In addition the metasoma is petiolated. Hence these bees belong to the sub order Apocrita.

Blue banded bees are long tongued bees because their glossa is elongated and end in a flabellum for licking nectar. Further the first two segments of labial palp are longer and the last two segments are smaller. Since the forewing has three submarginal cells and the pollen collecting apparatus (scopa) is present on hind leg, these bees are grouped under Apidae. Since the paraglossa is shorter than the combined length of the first two segments of the labial palp and clypeus is protuberant these bees are classified under the sub family Apinae and tribe Anthophorini.

The bees are placed under the genus *Amegilla* because their legs lack arolia (Brooks, 1988) [2] and metasoma is with blue metallic markings. In addition, the first recurrent vein joins the second submarginal cell near the midpoint. The distance between front and rear margin & distal and basal margin of third submarginal cell are of equal length. They are categorized under the subgenus *Zonamegilla* because the maxillary palp is six segmented and the gonostylus of male is reduced to a blister. The bees belong to the species *zonata* because the number of metasomal bands varies in male and female. The male bee has five metallic, pubescent bands and the female bee has only four bands. Hence, these bees are popularly called blue banded bees. Similarly clypeal markings also vary between sexes. Markings on the clypeus are prominent in female bee where as they are totally absent in male bee (Engel, 2007) [3].

Like eusocial bees blue banded bees also show sexual dimorphism. The important structural variations between the sexes are tabulated in Table 3.

This phenomenon of sexual dimorphism was clearly shown by *A. zonata* in our studies. The female bee was comparatively longer and larger than male. Markings on clypeus and number of metallic pubescent bands on the gaster were very much useful to distinguish the sexes. The metallic colouration of the gaster results due to iridescence. Beautiful colouration results due to microscopic diagonal stripes on each hair. These lines break up the light producing glittering blue colour. The mandibles of female are longer (Table 2) and well suited for fossorial nesting. The drones of eusocial bees always have holoptic compound eyes which are larger and closely placed. However, in blue banded bees the compound eyes are slightly larger in female than in male. The flagellar variation in these bees is similar to true honeybees. More flagellomeres in male may be of use in effectively in mate location during nuptial flight. Blue banded bees are long tongued bees since the glossa the main constituent of lapping tongue is fairly long to tap the nectar effectively from deep seated nectaries.

Table 2: Comparative morphometric measurements of male and female bees of *Amegilla zonata*

Sl. no	Body characters (mm)	Male bee	Female bee	Test of significance
1	Body length	10.81±0.18	12.14± 0.21	Significant
2	Length of head	2.88 ± 0.06	2.88 ± 0.06	Non-significant
3	Width of head	4.07 ± 0.03	4.64± 0.03	Significant
4	Length of Compound eye	2.46 ± 0.06	2.71 ± 0.05	Significant
5	Width of Compound eye	1.25 ± 0.02	1.47 ± 0.04	Significant
6	Length ofscape	0.59 ± 0.02	0.76 ± 0.02	Significant
7	Length of pedicel	0.17 ± 0.00	0.16 ± 0.00	Non-significant
8	Length of F1	0.36 ± 0.01	0.58 ± 0.01	Significant
9	Inter antennal distance	1.03 ± 0.02	1.25 ± 0.03	Significant
10	Antenno-ocellar distance	0.91 ± 0.01	0.98 ± 0.03	Significant
11	Upper IOD	2.12 ± 0.02	2.42 ± 0.02	Significant
12	Lower IOD	1.87 ± 0.01	2.20 ± 0.02	Significant
13	Length of the mandible	1.23 ± 0.03	1.46 ± 0.05	Significant
14	Length of mesosoma	3.13 ± 0.07	3.62 ± 0.07	Significant

15	Width of mesosoma	3.47 ± 0.07	4.04 ± 0.07	Significant
16	Length of forewing	7.64 ± 0.15	8.74 ± 0.14	Significant
17	Length of hindwing	5.39 ± 0.11	6.28 ± 0.11	Significant
18	Length of 1 st S.M.C	0.51 ± 0.02	0.58 ± 0.02	Significant
19	Length of 2 nd S.M.C	0.53 ± 0.01	0.56 ± 0.01	Non-significant
20	Length of 3 rd S.M.C	0.49 ± 0.01	0.56 ± 0.01	Significant
21	Length of fore tibia	1.59 ± 0.04	1.93 ± 0.05	Significant
22	Length of fore basitarsus	1.35 ± 0.08	1.49 ± 0.04	Non-significant
23	Length of hind tibia	2.59 ± 0.08	3.23 ± 0.06	Significant
24	Length of hind basi tarsus	1.91 ± 0.05	2.02 ± 0.06	Non-significant
25	Length of metasoma	5.16 ± 0.21	6.01 ± 0.20	Significant
26	Width of metasoma	4.67 ± 0.04	5.32 ± 0.07	Significant

IOD-Inter Orbital Distance

S.M.C-Sub Marginal Cell

*Student's t-test

Table 3: Sexual dimorphism in *Amegilla zonata*

Sl.no	Characters	Male bee	Female bee
1	Body length	Short	Long
2	Clypeal markings	Absent	Present
3	Mandible	Short	Long
4	Antenna	Long	Small
5	No. of flagellomeres	Eleven	Ten
6	Compound eye	Small	Long
7	Bands	Five	Four
8	Sting	Absent	Present



Fig 4: *Amegilla zonata* female with clypeal markings



Fig 1: *Amegilla zonata*-Male

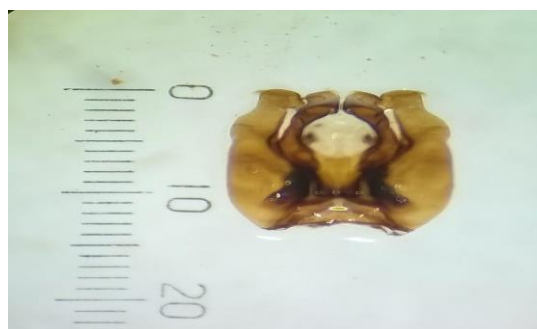


Fig 5: Male genital capsule of *Amegilla zonata*



Fig 2: *Amegilla zonata*-Female



Fig 6: Seventh metasomal sternite (S7) of *Amegilla zonata*



Fig 3: *Amegilla zonata* male without clypeal markings

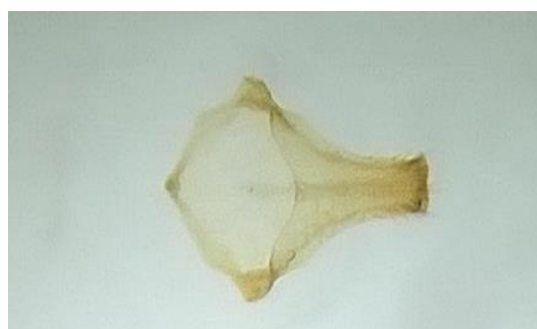


Fig 7: Eighth metasomal sternite (S8) of *Amegilla zonata*

5. Conclusion

The present study is a contribution of systematics of Blue banded bees, *Amegilla zonata*. This research work helps in identification of these bees for pollination researchers and future work.

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