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Morphometric studies of subgenus *Megabombus* (Hymenoptera: Apidae) from Jammu and Kashmir, India

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Abstract

The subgenus *Megabombus* comprises remarkably long-tongued species of bumblebees and remains usually more specialized in their selection of diversity of floral plants than other bumblebees for pollen and nectar resources. The subgenus *Megabombus* is described by only a single species from the North West Himalayan belt viz., *Bombus albopleuralis* Smith. This species is mostly familiar to exist at low highland habitats in the Indian Himalayan region with a long seasonal activity and is widely spread throughout North West and eastern Indian Himalayan region. The different caste members of this species viz., Queen, worker and male were recorded from different selected sites in the Union territory of Jammu and Kashmir. A total of sixteen morphological characters of *Bombus albopleuralis* were studied and later on, measured to find out the variations in different castes of *Bombus albopleuralis* and subsequently help in the identification of their different castes.

Keywords: Caste, Hymenoptera, India, *Megabombus,* Morphometrics, Subgenus

Introduction

Bumblebees are considered some of the most indispensable and remarkable insect pollinators of wild flora as well as various agrarian habitats in temperate regions (Velthius & Doorn, 2006; Goulson, 2010). They have commonly remained a popular insect group of study for several insect collectors and early naturalists due to their protuberant appearance, working activity hours and richness in north temperate regions (Williams, 1998). The long-tongued species of bumblebees have a more specialized preference for floral plants than short-tongued bees for food resources (Prys-Jones, 1982; Goulson & Darvill, 2004; Kawalita *et al.*, 2004; Goulson *et al.*, 2006). It has been revealed that the genus *Bombus* is morphologically characterized by a medium to large body size ranging from 9 to 22 mm long, and through visible colour arrangements (Williams, 2007). These bees are able to displace pollen from anthers rapidly by performing buzz pollination (Wahengbam *et al.*, 2019). Except for honeybees and other lineages of bees, the bumblebee is the only group of insects that has been more extensively studied (Michener, 2007). The classification of *Bombus* based on hair colour is unpredictable as conspicuous colour patterns show resemblance among many species of bumblebees or it might be extremely fluctuating in a particular species (Terzo *et al.*, 2007). Globally the subgenus *megabombus* comprises extremely specialized and longest-tongued bumblebee species, in addition to this, this group also played a significant role in determining the length of tongue, and evolution of food specialization in bumblebees (Cameron *et al.*, 2007; Williams *et al.*, 2008). After extensive taxonomic revisions, there are approximately 22 species placed in subgenus *Megabombus* (Williams, 1998). In Jammu and Kashmir, *Bombus albopleuralis* Smith is the most dominant species among bumblebees and has an extremely broad choice of host plants (Raina *et al.*, 2017). It is immensely considered to provide pollination service to a variety of native plants and cultivated crops in low-highland

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ecosystems of the Indian Himalayas (Saini *et al*., 2012). To overcome the challenges in identifying and separating different species of bumblebees, it was important to employ morphometric techniques. Keeping in view the importance of caste differentiation in bumblebees for their successful rearing, present studies were conducted to know the morphological differences in different castes of *Bombus albopleuralis.*

Materials and Methods

Morphometric studies were performed on the queen, worker and male caste of *Bombus albopleuralis* belonging to subgenus *Megabombus*. All the specimens of the targeted species were collected during three years from 2019 to 2021 of consecutive studies from different districts of the Union territory of Jammu and Kashmir (33.2778^{0}N, 75.3412^{0}E), covering various sampled sites (Figure 1). The coordinates of the sampled sites were collected with a hand-held GPS device. In the field, these bees were killed using ethyl acetate in a killing bottle and later on as per the technique adopted by Ruttner *et al.* (1978) specimens were preserved in 90% ethanol and brought to the National Zoological Collection (NZC) at Desert Regional Centre, Zoological Survey of India, Jodhpur, Rajasthan, India. All the preserved specimens were dissected into many body parts and each part to be measured was carefully put on clean slides, later all measurements were documented under a high-resolution scanner (11001p/mm) directly

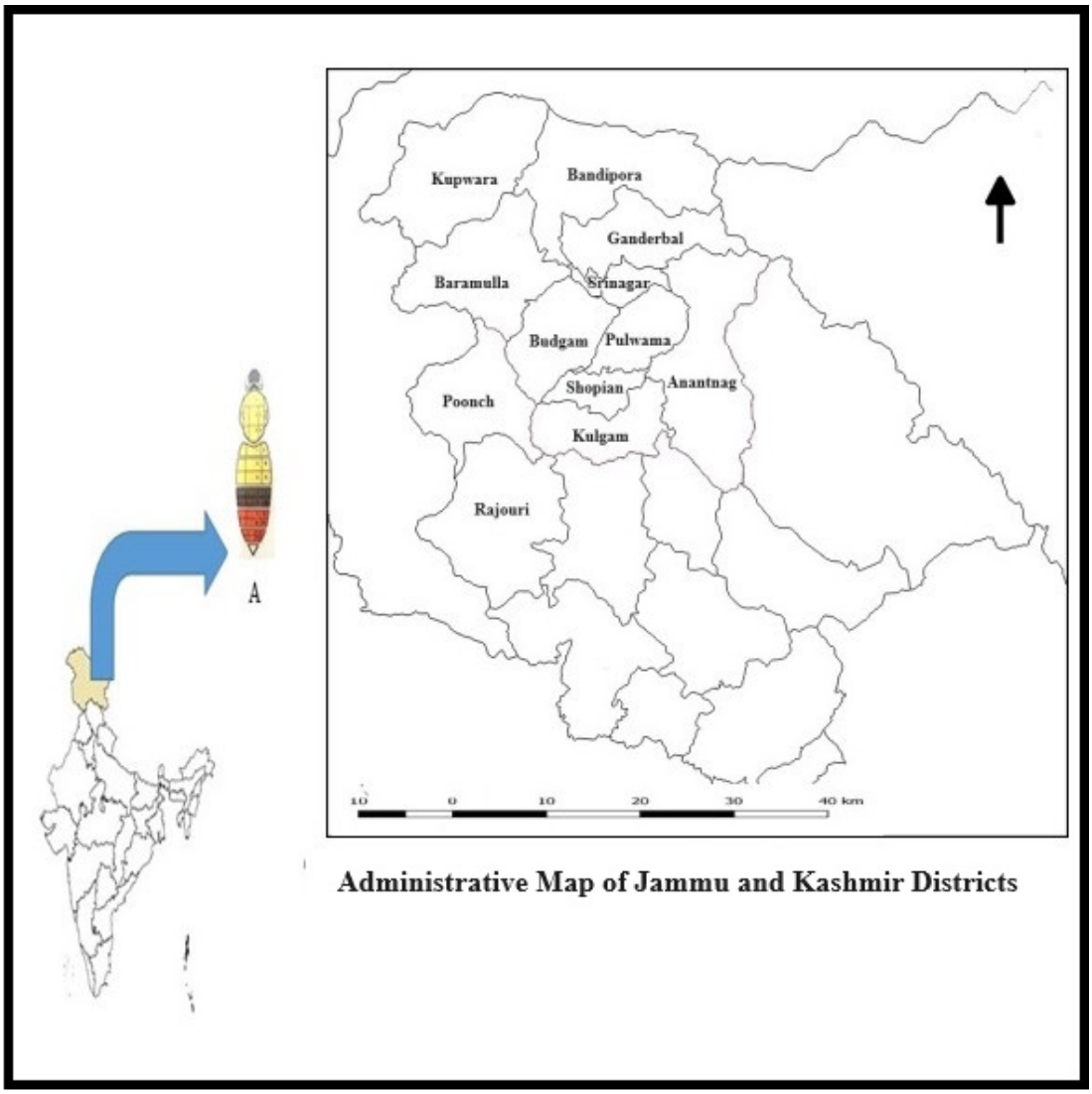

Figure 1. Map showing the sampled habitats in the Union Territory of Jammu and Kashmir.

connected to a desktop computer system supported with NIS-Elements software D.5.21.03, 64-bit. Hence, in the current study total of sixteen morphometric parameters of the queen, worker and male caste of *Bombus albopleuralis* were studied associated with their size of body, length of tongue, length of Antenna, number of hamuli, length and breadth of forewing and hind wing and also the length of legs.

Results

The comparative morphometric data obtained from the study of the Queen, worker and male of *Bombus albopleuralis* are given in tabulated form and are also supported by images from A_1 to C_8 (Plate 1-3). In *B. albopleuralis* the various morphometric parameters measured relating the total body length of different castes of queen, worker and male are 19.24 mm, 11.9 mm and 13.93 mm respectively. The study also revealed the total length of the tongue in the respective castes of *B. albopleuralis* was separately measured as 10.92 mm, 6.32 mm and 6.27 mm. In *B. albopleuralis* the antenna length was recorded to be longest in the queen (8.48 mm) followed by the male (7.97 mm) and smallest in the worker (5.75 mm) respectively. During the investigation, it was found that the flagellum of the antenna contains 10 segments in both castes of queen and worker of *B. albopleuralis* but had 11 segments in male castes of the respective species. The length and breadth of forewings of *B. albopleuralis* were individually recorded as 21.56 mm; 6.69 mm, 11.71 mm; 3.59 and 13.90 mm; 4.12 mm in queen, worker and male respectively. Likewise, the measurements of the length and breadth of the hindwing of their respective castes were recorded as 14.88 mm; 3.78 mm, 8.19 mm; 2.05 mm and 9.20 mm; 2.03 mm. During the morphometric study of hindwings, it was observed that hamuli were present in all three castes of *B. albopleuralis*. However, a number of hamuli vary from 28, 21 and 20 in queen, worker and male respectively. In addition to this, varied differences were found in the legs of all castes of *B. albopleuarlis* as mentioned in Table 1.

Table 1. Morphometric data of different castes of *Bombus albopleuralis*

Table: 1	Characters	*B. albopleuralis*		Queen (♀)			Worker (♀)			Male (♂)		
		Total body length (mm)		19.24			11.9			13.93		
		Total length of Tongue (mm)		10.92			6.32			6.27		
		Antenna (mm) length	scape	2.71			1.73			1.32		
			Pedicle	0.27			0.25			0.23		
			Flagella	5.50			3.77			6.42		
			Total Length	8.48			5.75			7.97		
		Forewing (mm)	Length	21.56			11.71			13.90		
			Breadth	6.69			3.59			4.12		
		Hindwing (mm)	Length	14.88			8.19			9.20		
			Breadth	3.78			2.05			2.03		
			No. of Hamuli	28			21			20		
		Legs (mm) length		Fore leg	Mid leg	Hind leg	Fore leg	Mid leg	Hind leg	Fore leg	Mid leg	Hind leg
			Coxa	1.95	2.82	1.80	1.15	2.21	1.63	1.12	2.26	1.50
			Trochanter	1.05	1.14	1.01	1.24	1.21	1.02	1.09	1.31	0.82
			Femur	3.08	3.41	4.25	2.16	2.89	3.23	2.23	2.90	3.62
			Tibia	2.29	2.74	4.33	2.34	2.70	3.60	2.52	2.96	4.00
			Tarsus	3.39	5.81	6.37	3.53	5.41	5.78	3.86	6.00	6.68

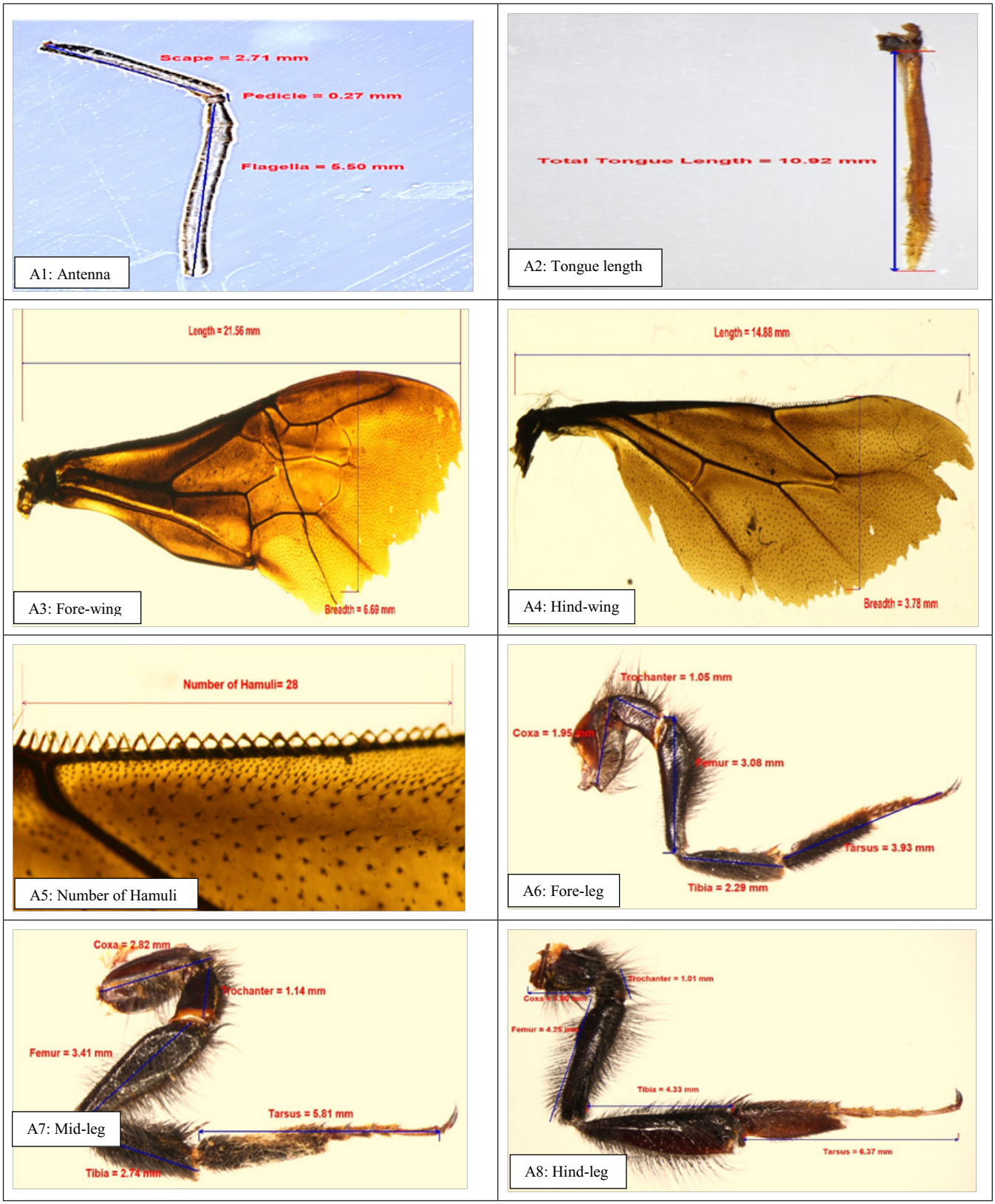

Plate 1. Morphometric images of *Bombus albopleuralis* Queen (♀)

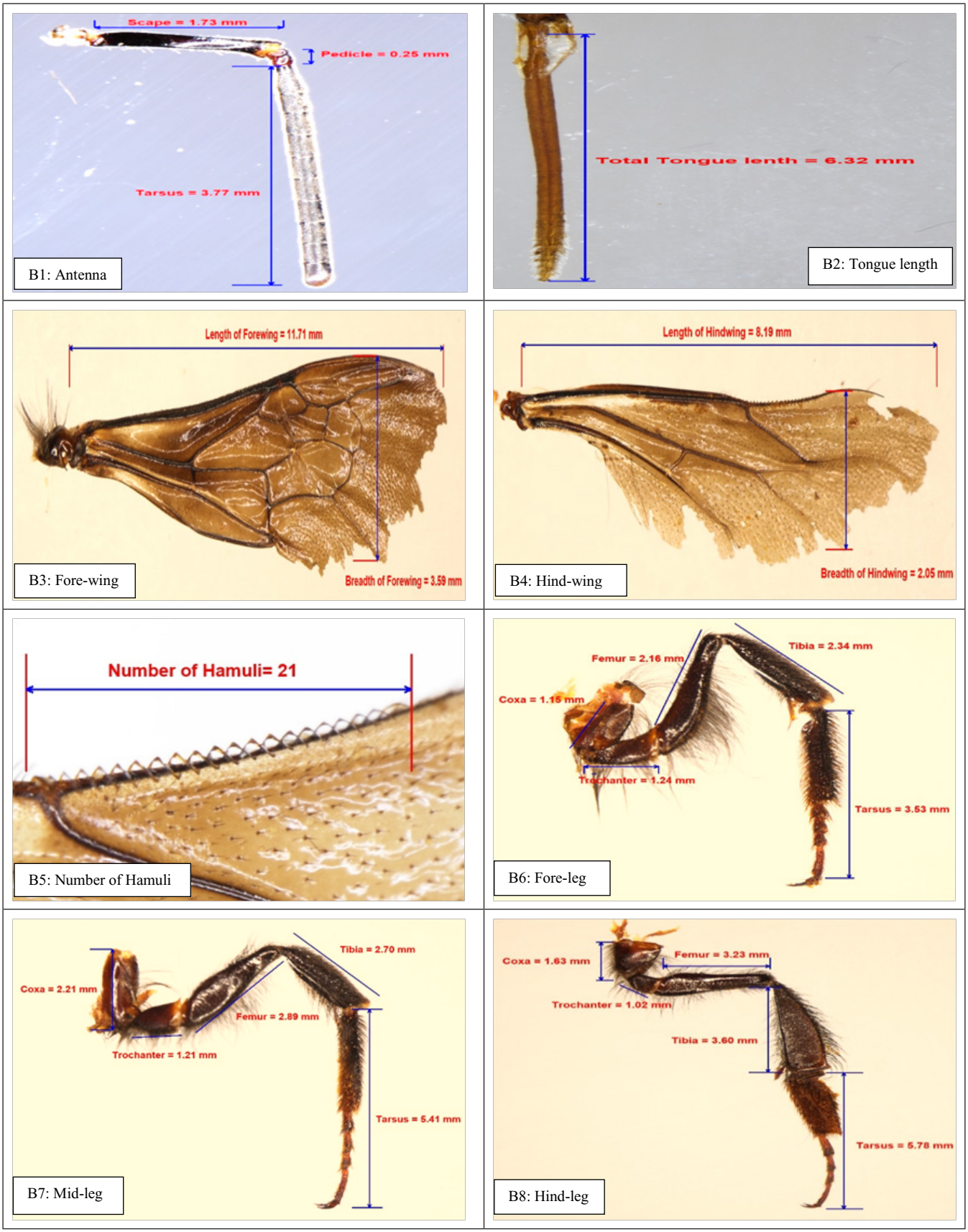

Plate 2. Morphometric images of *Bombus albopleuralis* Worker (♀)

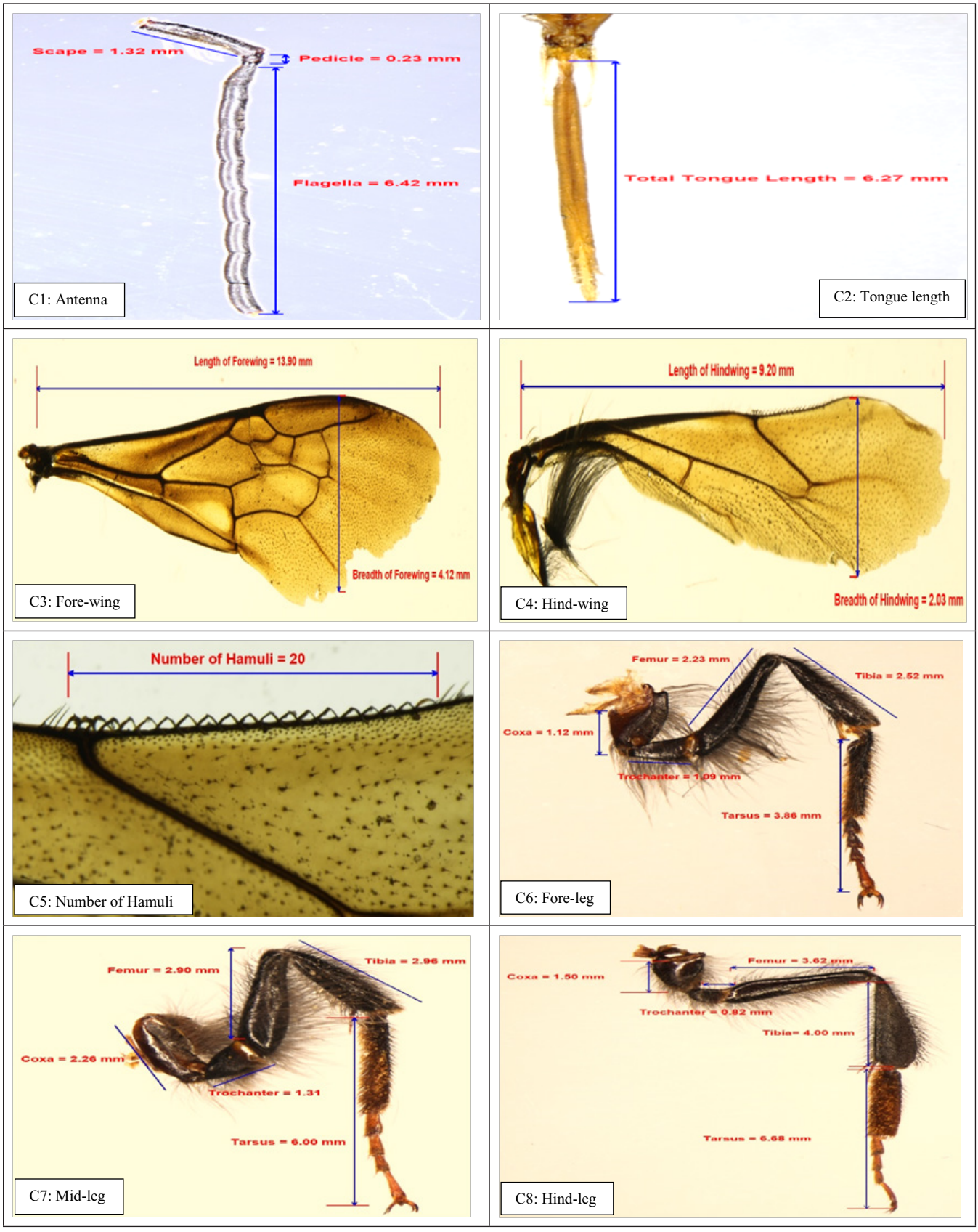

Plate 3. Morphometric images of Bombus albopleuralis Male (♂)

Discussion

Concerning morphometrics great variations in the length of the tongue were found in all the castes of *B. albopleuralis*. The tongue length of the queen was constantly larger than the worker and male caste of *B. albopleuralis*. Therefore the queen of *B. albopleuralis* will commonly harvest more pollen and nectar from flowering plants than workers. It has been seen that bumblebee and floral interactions are facilitated by bumblebee tongue length and floral tube length (Struttmann *et al*., 2014). The queen of *B. albopleuralis* is bigger and directly helps in the efficient loading and transportation of nectar and pollen from flowers than the worker and male of their respective castes. It was predicted that there is a direct relationship between the size of the bumblebees and the total quantity of nectar collected per flower (Schoener, 1969). Morphometric studies were previously performed in different castes of *B. haemorrhoidalis* and revealed differences in the characteristics such as body parts and size of the body of their respective castes (Dayal & Rana, 2007; Chauhan *et al*., 2016). It was found that a maximum number of hamuli was found in the hindwings of the queen as compared to the worker and male castes of *B. albopleuralis*. Moreover, it has been observed that different activities of the bees are carried out by these significant morphological structures which are found in bumblebees. Similarly, the morphometric investigation of the legs revealed that the hind legs of the queen are larger, followed by the worker and male caste of *B. albopleuralis*. The hind legs of the queen and worker contain corbicula or pollen basket which facilitate in transportation of pollen grains from the same flowers and thus support pollination services. While in the male caste, the corbicula is less developed or absent. Thus morphometric methods applied on different morphological structures have shown a great variation in queen, worker and male caste of *B. albopleuralis*. The different morphometric data in this study based on the length of the tongue, size of the body and other important factors help biologists to comprehend and predict the behaviour of bumblebees. Due to large foraging activity and the availability of a diversity of flowering plants in Kashmir Valley, it was found that the size of all castes of *B. albopleuralis* was constantly larger. It has been concluded that *B. albopleuralis* is a remarkably long-tongued species of bumblebees and has a more specialized choice of flowering plants for food resources. The *B. albopleuralis* is a dominant species in the Kashmir region and hence its morphometrics studies will subsequently help in the identification of different castes of *B. albopleuralis* which further helps in devising strategies for the development of rearing and conservation methods of this important bumblebee species.

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