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## Taxonomy and ecology of *Bombus trifasciatus* Smith (Hymenoptera: Apidae: *Megabombus*) from Indian Himalaya with description of new variants

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### Abstract

*Bombus trifasciatus* Smith 1852 is very variable in colour pattern. Queens differ in colour of abdominal tergum 3 with yellow and black; while workers have abdominal tergum 3 yellow and brick red; lateral aspects of thorax are white in some individuals. Due emphasis has been laid on its detailed taxonomic descriptions, food plants, population variation, synonymy, distribution pattern and illustration. Many new food plants of this species have been recorded for the first time from the area under study.

**Keywords:** *B. trifasciatus*, taxonomy, population variation, food plants, Indian Himalaya

### Introduction

*Bombus trifasciatus* (Smith, 1852) is an Oriental species. In India this species is commonly known to occur at low altitudes with a long seasonal activity. It is widely distributed in Kashmir, Himachal Pradesh, Uttarakhand, West Bengal (Darjeeling), Sikkim, Arunachal Pradesh, Manipur, and Meghalaya Saini *et al.* <sup>[1]</sup>. Its population is very high in the field and it emerges very early at the start of the season (i.e. May). In Jammu and Kashmir Himalayas its members were recorded from the foot hills of Pir Panjal range and lower mountains of coniferous forest during May-September. Queens and workers prefer to forage on *Cirsium* spp. (Asteraceae) and some selected members of Balsaminaceae and Ranunculaceae. This species has altitudinal distribution ranging from 1700-2400m amsl. On the basis of some morphological features, sex, caste and colour pattern there is a lot of intra-specific population variation of the species. This problem is so acute that some time it is difficult to put different variants under the same species. Prior to Williams <sup>[2]</sup> based on colour pattern, some unstable and ambiguous morphological features, size and sex there were 172 species from Indian sub continent. Bingham <sup>[3]</sup> compiled 23 species in fauna of British India that included some records from the neighbouring countries; as Myanmar, Bhutan, Nepal, etc. Subsequent workers added 149 species to this list, raising the total species number to 172, but due to lot of synonymy as put forth by Williams <sup>[2]</sup>, only 47 species stand as valid. Genus *Bombus* is at present represented by 48 species from India out of which 37 species are reported from North West Himalaya Saini *et al.* <sup>[1]</sup>.

However, Williams <sup>[2]</sup> made a detailed study and taking male genitalia, sculpture, topography and labrum and clypeus and some other stable ratios and synonymized most of the species thus reducing the number of valid species to only 47. There are 250 valid species of bumblebees present on global basis Williams <sup>[4]</sup>, whereas only 48 species of these bees are known from Indian Himalaya (Williams <sup>[5]</sup>; Saini *et al.* <sup>[2]</sup>). Some important works regarding the economic importance of the species under study and its association with entomophilous flowering plants include (Smith, <sup>[6, 7]</sup>; Dalla Torre <sup>[8]</sup>; Richard <sup>[9]</sup>; Skorikov <sup>[10]</sup>; Tkalcu <sup>[11-13]</sup>; Williams <sup>[14]</sup>; Yin *et al.* <sup>[15]</sup>; Williams *et al.* <sup>[16]</sup>; Burger *et al.* <sup>[17]</sup>; Saini *et al.*, <sup>[18,19]</sup>).

The present study is designed to explore food preference and ecological distribution pattern, detailed taxonomic description, population variations, taxonomic illustrations of the *B. trifasciatus* from North-west Himalayan belt as this region forms a natural unit of taxonomic coverage for the genus *Bombus*.

### Materials and Methods

The specimens treated for the present studies was collected during the last 10 years (2007-2016) from various localities viz. Gulmarg, Pahalgam, Anantnag, Baramulla, Kishtwar,

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Srinagar, Udhampur, Palampur, Mandi, Shimla situated in the North west Himalayan belt falling in an altitudinal range of 1000-5500m. Sampling was conducted at sites dominated by the most representative vegetation types of the region. Altitude of each site was measured with digital altimeter. The insects were collected with sweeping hand net made and the latter were killed with ethyl acetate. In addition to collection the live photography of the species under study was done with Olympus camera equipped with different macro lenses. The microscopic examination of various morphological features was performed with the help of binocular microscope fitted with an ocular grid. All the food plants of species were collected side by side and got identified from the Centre of Plant Taxonomy, University of Kashmir.

Specimens treated in this study are deposited in the following public collections:

ZDPUP: Department of Zoology, Punjabi University, Patiala, India.

DESKUASTK: Division of Entomology SKUAST-K Shalimar J&K, 191121, India

#### Abbreviations used in the text

AS-III – IIIrd antennal segment, AS-IV – IVth antennal segment, AS-V – Vth antennal segment, AU – auricle; amsl– Above mean sea level, BMB: Breadth mandible at its base; LF:Length of flagellum ; LHB:Length of head breadth; LS:Length of scape; MS:Length of malar space; OOL:Ocello ocular length ; POC:Post ocular line; POL: Post ocular length, CA– corbicular area, DAC –distoanterior corner, DPC – distoposterior corner, DPM – distal posterior margin, LM – lamella, LOB – length of basitarsus, LS – length of scape, LT – lateral tubercle, MBB – breadth of metabasitarsus, MF – median furrow, MT – mandibular teeth, TB – tibia, amsl – above mean sea level.

#### Results and Discussion

In the present communication many new variants of *B. trifasciatus* are discussed. In addition to providing diagrammatic colour pattern of all the variants, many new host plants are added. Williams confirmed his findings still further by making the molecular analysis of different variants under study.

#### Systematics

##### *Bombus (Megabombus) trifasciatus* Smith, 1852

*B. trifasciatus* Smith 1852: 43, Lectotype queen, China:Zhejiang (BMNH), Richards, 1931: 529-31; Panfilov 1957: 235; Sakagami 1972: 158; Tkalcu 1974: 344; Williams, 1991: 52; Yao & Wang 1993: 768; Yao 1995: 579, 1998: 403; Yao & Luo 1997: 1686; Yin *et al.*, 2001: 753; Burger *et al.*, 2009: 46.

#### Synonymy

*B. montivagus* Smith, 1878: 168  
*B. secundus* Dalla Torre, 1890: 139  
*B. ningpoensis* Friese, 1909: 676  
*B. wilemani* Cockerell, 1911: 100  
*B. haemorrhoidalis* var. *albopleuralis* Friese, 1916: 108  
*B. maxwelli* Pendlebury, 1923: 67  
*B. (Hortobombus) mimeticus* Richards, 1931: 529  
*B. (Diversobombus) malaise* Skorikov, 1938: 2  
*Megabombus (Diversobombus) montivagus* subsp. *quasibreviceps* Tkalcu, 1968: 27

*Megabombus (Diversobombus) albopleuralis* subsp. *atropygus* Tkalcu, 1989: 58

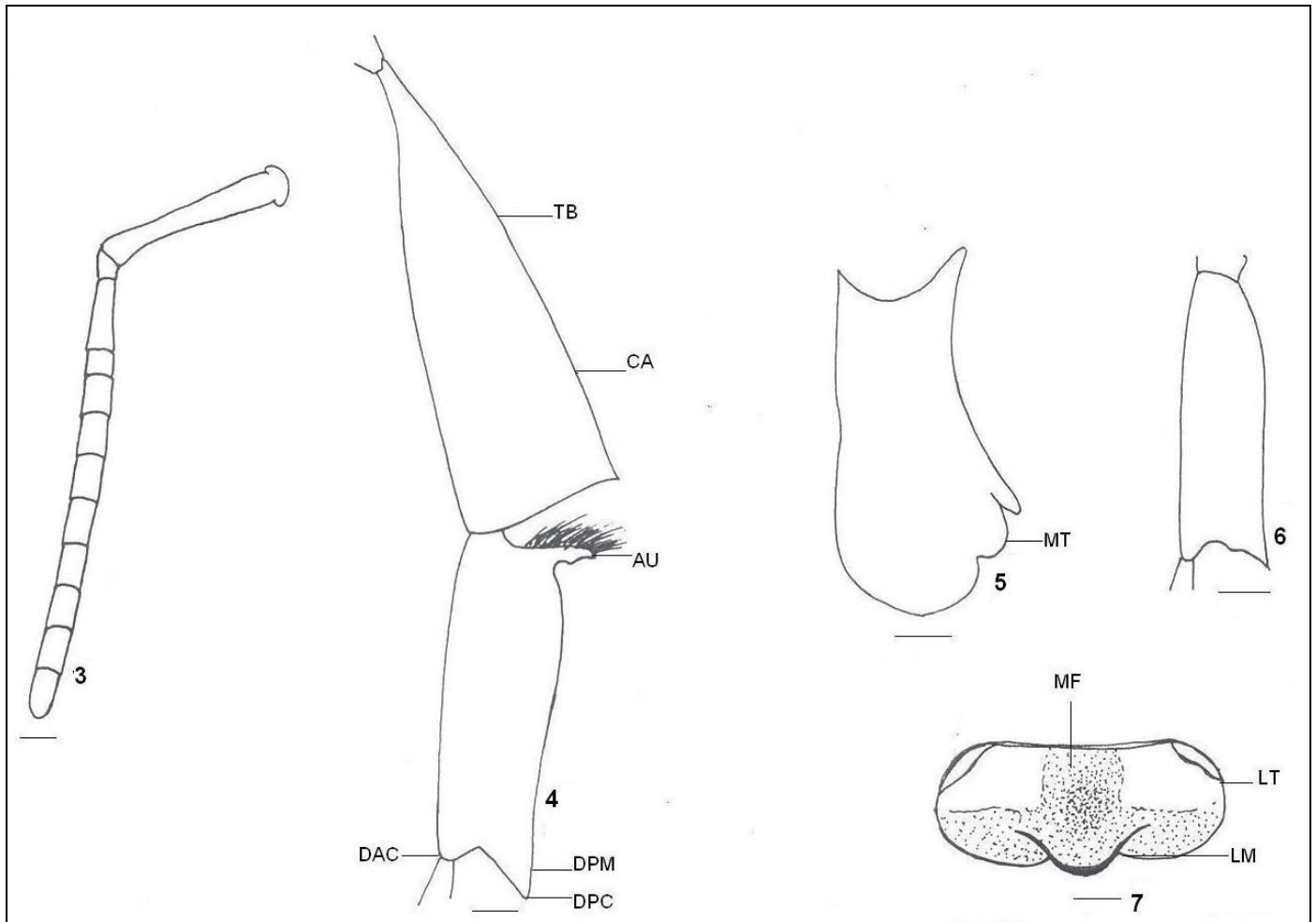
**Female:** (Figs. 1, 2) In queens pubescence on head and thorax black; abdominal tergites 1-3 yellow, brick red are abdominal tergites 4-5. Workers with head and thorax black; abdominal tergites 1 and 2 yellow; brick red are: abdominal tergites 3-5. Mandible as illustrated (Fig. 5). Labrum with basal transverse depression extending apically as a deep median furrow between pronounced lateral tubercles, which are bluntly raised, displacing ridge between them to form a lamella that overhangs apical margin (Fig. 7). Head covered with thick pubescence except malar space; the meso basitarsus with the distal posterior corner produced as a narrow sharp spine; the length of distoposterior corner little longer than the length of distoanterior corner (Fig.6); metabasitarsus with dense pubescence of proximal margin (auricle) continuing on to the outer surface of proximoposterior projection as just few sparse hair, length of projection longer, nearly 2 times its breadth at its base; distal half of its posterior margin concave with a distoposterior corner spinosely pointed and longer than distoanterior one (Fig.4). Oculo-malar distance approximately 1.7 times the proximal breadth of the mandible; dorsum of the head with punctures scattered almost throughout except in the ocellar depressions; antennal segment 4 just shorter than broad, half of the length of segment 3; antennal segments 3:4:5=1.40:0.50:1; LF: LS: LHB=10.25:5:11 (Fig. 3). Wings dark brown. Clypeus with many large punctures throughout.



Fig 1: *B. trifasciatus* (queen)



Fig 2: *B. trifasciatus* (worker)



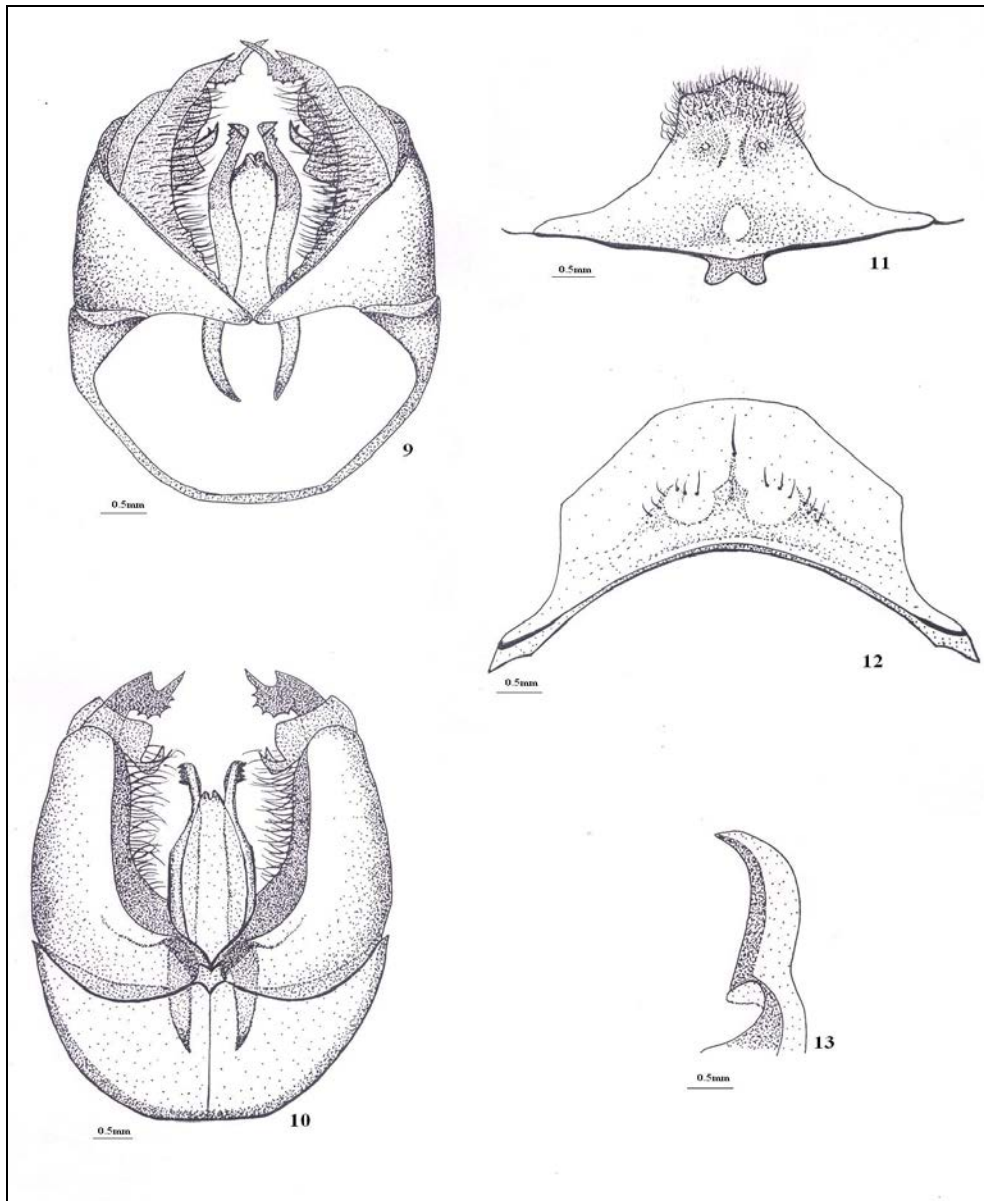
**Fig 3-7:** Female: 3. antenna, 4. metabasitarsus 5. mandible 6. mesobasitarsus, 7. labrum. Scale bar = 0.5 mm.

**Male:** (Fig. 8) Head and abdominal tergum 3 black; thorax black with lateral aspects white; yellow are abdominal tergites 2-3; brick red are: abdominal tergites 3 and 4. Anterior margin of labrum with a slight median notch (Fig.16). Lateral tubercles interrupted in centre due to very fine groove which is intermingled with macropunctures. Compound eyes unenlarged relative to that of female and the antenna long, reaching posteriorly to the wing bases; a band of micropunctures very close to eye margin covering a negligible area between lateral ocellus and eye margin. OOL: POL=2:2.5. The lateral ocelli are just below the POC, their upper margins touching the POC. Antennal segments 3:4:5=1.5:1:2; LF: LS: LHB=9.5:2.5:6.5 (Fig. 14). Genitalia with the penis valve distally short, weakly flared and head toothed; gonostylus short and broad, nearly rectangular, with two long recurved spine-like inner proximal processes; volsella with the inner hooks very close to the distal corner, with the distally directed hook spinose and nearly straight or weakly 'S'-shaped, the proximally directed hook strongly recurved, as long or longer than the distal hook, and broadly flattened with many radiating. Gonostylus with interio-basal process strongly produced, with both an apically directed hook and a more ventrally directed hook; volsella with inner hooks very close to apical corner, the large apically directed hook nearly straight and spinose, the basally directed hook

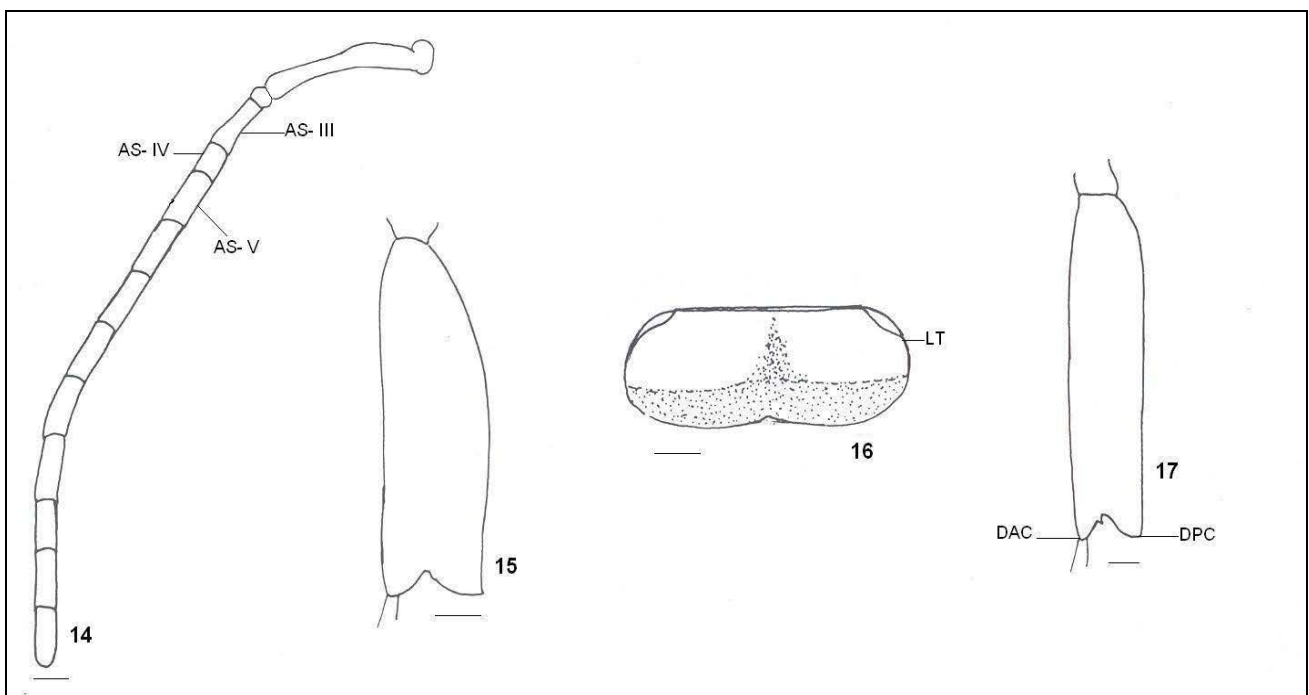
strongly recurved and broad with many teeth, both hooks projecting beyond gonostylus from dorsal aspect, part of volsella immediately proximal to inner hooks much narrowed; head of penis valve twice as broad as shaft, from dorsal aspect, with pronounced teeth along outer lateral ridge (Figs. 9-13).



**Fig 8:** *B. trifasciatus* (male)



**Figs 9-13.** Male genitalia: 9. ventral aspect; 10. dorsal aspect; 11. penis valve, lateral view; 12. 8th sternite; 13. 7th sternite. Scale bar = 0.5 mm.



**Figs 14-17.** Male: 14 – antenna, 15– metabasitarsus, 16 – labrum 17 – mesobasitarsus. Scale bar = 0.5 mm.

**Material examined**

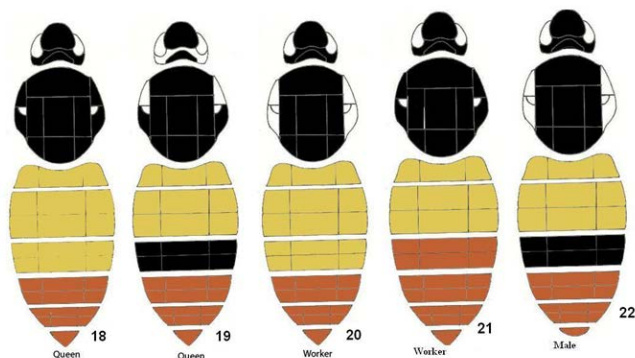
**Anantnag:** Aru, 2950m, 12♀♀, 28.vi.2010; 4♀♀, 22.vi.2014. Baisaran, 2533m, 9♀♀, 29.viii.2008, 8♀♀ 22.vi.2014; Chandanwari, 2900m, 6♂♂ 15.viii.2010. Kullar, 2100m, 24♀♀, 17♂♂, 28.viii.2008; Pahalgam, 2400m; 9♀♀, 23♂♂, 30.viii.2008. Baramulla: Gulmarg, 2843m, 24♀♀, 15.vi.2010; Kongdori, 3000m, 12♀♀, 16♂♂, 2.viii.2009, 8♂♂, 4.viii.2016 Kishtwar: Padder, 2800m; 6♀♀, 12♂♂, 28.ix.2008. Udhampur: Patnitop, 2100m, 2♀♀(q), 3♂♂, 2♀♀ 14.viii.2007, 25.ix.2008. Budgam: Doodpathar, 2890m, 3♀♀(q), 25♀♀, 14♂♂, 4.ix.2007, 15.vi.2008; 7♂♂, 22.vi.2015. Kralpathar, 2340m, 12♀♀(q), 15♀♀, 04.vi.2007. Budgam: Yousmarg, 2600m, 13♀♀ (q), 27♀♀, 21.v.2007, 19.vi.2010. Ganderbal: Baltal, 3350m, 12♂♂, 5.vii.2010. Srinagar: Kashmir Botanical garden, 1627m, 12♀♀(q), 46♀♀, 10.v.2007, 10.vi.2008; Himachal Pradesh: Palampur, 1200m, 8 ♀♀ (q), 22 ♀♀, 22.6.2007, 10.8.2008; Mandi: Joginder Nagar, 1300 m, 12 ♀♀, 24.6.2007, Shimla: Chail, 2100 m, 14 ♀♀, 27.6.2007; Theog, 2600 m, 5 ♀♀, 29.6.2007. (Collection Rifat H. Raina).

**Global distribution:** Himalaya, Myanmar, Peninsular Malaysia, Thailand, Vietnam, Laos, China, Taiwan, Pakistan, Nepal, Tibet Bhutan. (Williams, 2004).

**Distribution within India:** Kashmir, Himachal Pradesh, Uttarakhand, Darjiling Bengal, Sikkim, Arunachal Pradesh, Manipur, and Meghalaya. (Williams, 1991, Saini *et al.* 2011).

**Holotype depository:** NH Museum, London.

**Population variation:** (Figs.18-22) This species is very variable in colour pattern. Queens differ in colour of abdominal tergum 3 with yellow and black; while workers have abdominal tergum 3 yellow and brick red; lateral aspects of thorax are white in some individuals.



**Figs 18-22.** Colour pattern: 18-19 – queen, 20-21 – worker, 22– male

**Food plants:** (Figs. 23-27) *Pteracanthus urticifolius* (Kuntze) Bremek (Acanthaceae); *Hedera nepalensis* K. Koch (Araliaceae); *Artemisia absinthium* L., *Artemisia* sp., *Cirsium arvense*, *C. wallichii* DC., *Cirsium* spp. *Cynara scolymus* L., *Dahlia verbaalis*, *Helianthus annuus* L., *Tagetes patula* L., *Zinia elegans* Jacq. (Asteraceae); *Impatiens balsamina* L., *I. glandulifera* Royle, *I. sulcata*, *Impatiens* sp. (Balsaminaceae); *Incarvillea* sp. (Bignoniaceae); *Myosotis sylvatica*. Ehrh. ex Hoffm. (Boraginaceae); *Buddleja paniculata* Clarke (Buddlejaceae); *Convolvulus* sp. (Convolvulaceae); *Brassica* sp., *Raphanus sativus* L. (Brassicaceae); *Cucurbita pepo* L. (Cucurbitaceae); *Rhododendron* sp. (Ericaceae); *Marrubium vulgare* L., *Salvia* sp., *Stachys sericea* Wall. ex Benth.

(Lamiaceae); *Lavatera cashmeriana* Camb., *Malva neglecta* Wall. (Malvaceae); *Lotus corniculatus* L., *Lupinus polyphyllus* Lindl. (Papilionaceae); *Delphinium ajacis* L. (Ranunculaceae); *Digitalis lanata* Ehrh. (Scrophulariaceae); *Lycopersicon esculentum* Mill., *Solanum nigrum* L. (Solanaceae). The results of Williams <sup>[14]</sup> also in conformity with our findings who reported only *Pteracanthus urticifolius* (Kuntze) Bremek (Acanthaceae); *Cirsium wallichii* DC. (Asteraceae); *Impatiens glandulifera* Royle, (Balsaminaceae); *Stachys sericea* Wall. ex Benth. (Lamiaceae). Other food plants listed above are recorded for the first time from the area under study.

**Stratification:** 1000-3000m amsl.



**Fig 23:** *B. trifasciatus* worker on *Cirsium arvense*



**Fig 24:** *B. trifasciatus* worker on *Digitalis lanata*



**Fig 25:** *B. trifasciatus* (workers) on *Dahlia verbaalis*



Fig 26: *B. trifasciatus* worker on *Delphinium ajacis*



Fig 27: *B. trifasciatus* worker on *elegans*



Fig 28: Collection site: Kongdoori, Zinia 3000m amsl.

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