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Redescription of Male Genitalia of Six Species of Genus *Orthetrum* Newman (Anisoptera: Libellulidae) from North West India

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ABSTRACT: The structure of the male secondary apparatus of six species belonging to genus *Orthetrum* Newman i.e. *O. brunneum brunneum* (Fonscolombe), *O. glaucum* (Brauer), *O. japonicum internum* Maclachan, *O. pruinosum neglectum* (Rambur), *O. taeniolatum* (Schneider) and *O. triangulare triangulare* (Selys) have been redescribed and illustrated in detail based on the specimens from India. The importance of various morphological attributes like anterior lamina, hamule, vesicular spermalis and penis of male secondary apparatus have been highlighted based on this study.

Keywords: Morphology, male genitalia, *Orthetrum*, Libellulidae

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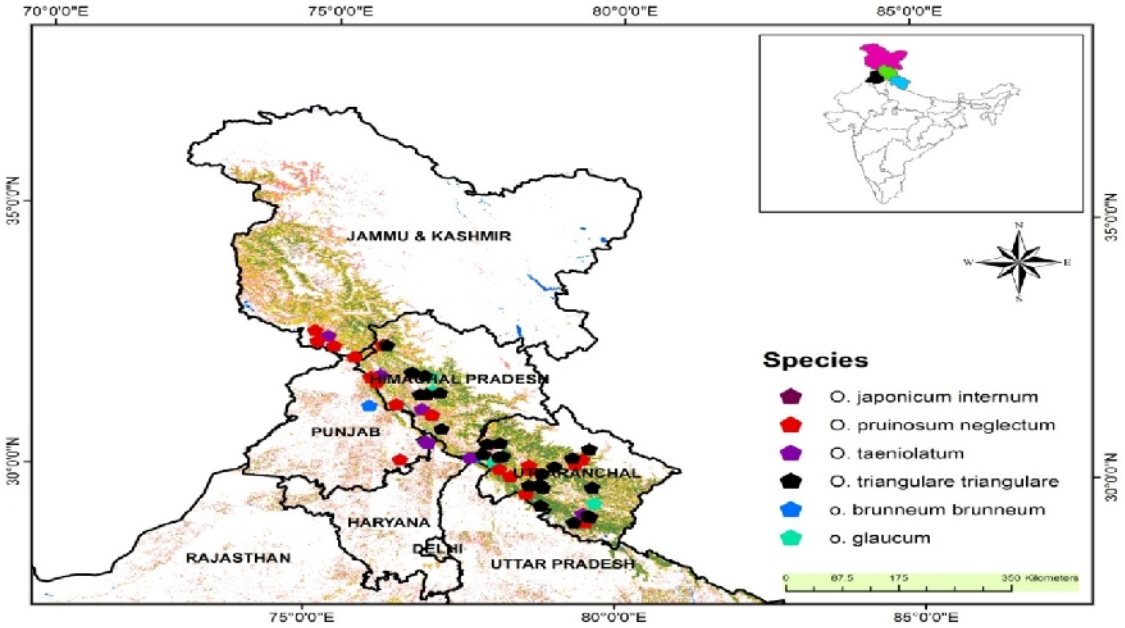
INTRODUCTION

The genus *Orthetrum* Newman, of sub-order Anisoptera belonging to family Libellulidae, is the largest genus of dragonflies with 63 species at global level (Odonata Central World Catalogue, 2017). It is represented by 12 species from India. All the species breed in still waters and in deep pools left by the falling rivers during the dry season. Few species, such as *O. japonicum internum* Maclachlan and *O. taeniolatum* (Schneider) are feral by nature while most species prefer to haunt cultivated areas. Probably due to this reason, majority of their breeding places are of an artificial origin. The male and female genitalia of six species i.e. *O. brunneum brunneum*(Fonscolombe), *O. glaucum*(Brauer), *O. japonicum internum* Maclachan, *O. pruinosum neglectum* (Rambur),*O. taeniolatum*(Schneider) and *O. triangulare triangulare* (Selys) have not studied and illustrated in details. In this manuscript, we reillustrate and redescribe these species based on the specimens collected by second junior author from North West Himalayas during the year.

MATERIALS AND METHOD

The adult dragonflies were collected with the help of insect collecting net from different localities of North-Western states of India including states like Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab and Uttarakhand in different seasons. The adult representatives of dragonflies were killed with ethyl acetate vapors in the killing bottle, and in case of teneral specimens or put alive into triangular paper packets and starved to death. The dead specimens were then bristled, pinned, stretched, dried and preserved. To examine the male genitalic structures, the whole abdominal segments were cut off either from the fresh specimens or dried ones. However, in latter case, the dragonflies were relaxed in insect relaxing box for 12 hours before detaching the abdomen. The separated abdomen segments were treated with 10% KOH to dissolve the muscles and to soften the chitin. The potashed material was washed in distilled water containing few drops of acetic acid. The dissection of abdomen was done in 50 % alcohol to have a clear view of different genitalic attributes. After proper dehydration, the material was preserved in vials containing a mixture of ethyl alcohol and glycerol. The sketches of the genitalia were made with the help of a graph eye piece under binocular microscope fitted with an ocular grid in one eye piece. The final drawings were rendered in black ink and illustrations were scanned and mounted onto plates in adobe photoshop. The genitalic terminology corresponds to Chao (1953) and Miller (1991). The specimens are deposited in Museum of Department of Zoology & Environmental Sciences, Punjabi University, Patiala, Punjab, India.

A total number of ten species of genus *Orthetrum* Newman were collected. Out of these, the distribution (Map. 1), diagnosis and male and female genitalic characters of six species have been illustrated here. Maximum number of species has been reported from Himachal Pradesh and least from state of Haryana (Table 1).



Map. 1. Map of North West India showing collection sites surveyed.

Table 1. Distribution of six species of genus *Orthetrum* Newman in North West India.

Species/ State	Jammu & Kashmir	Himachal Pradesh	Uttarakhand	Punjab	Haryana
O. brunneum		√√	√√	√√	
O. glaucum		√√	√√		
O. japonicum internum		√√		√√	
O. pruinosum neglectum	√√	√√	√√	√√	
O. taeniolatum	√√	√√	√√		√√
O. triangulare triangulare		√√	√√		

Description

***Orthetrum brunneum brunneum* (Fonscolombe)** (Figs. 1-8)

Fonscolombe. 1837, **6:141**.

Diagnosis: The subspecies under reference vary considerably in color, some having the sides of the thorax yellowish-white, others much darker. It resembles *O. anceps* (Schneider) very closely, but identified by double row of cells between IRiii and Rspl and shape of the genitalia of the male.

Male Genitalia: Lamina projecting markedly, dorsum studded with numerous black spines and few setae, apex slightly notched in middle; hamules with anterior border terminating into an extremely small and inconspicuous black hook, latter pointing outwards, posterior base black, deeply sclerotized, truncated in lateral view, separated by a narrow and deep cleft from hamular hook; genital lobes black, broadly constricted at base, apex globular bearing numerous small stiff marginally; vesicular spermalis elongated pear shaped, bearing moderately long stiff setae on dorsum; distal segment bearing a pair of dorsoventrally flattened lateral lobes, later joined by a small to distal segment, ventral surface of lobe bearing serrations; medial lobe well developed; flagellum bearing small proximally directed spines for its apical 1/3; apical lobe scoop shaped, bearing densely packed serrated scales.

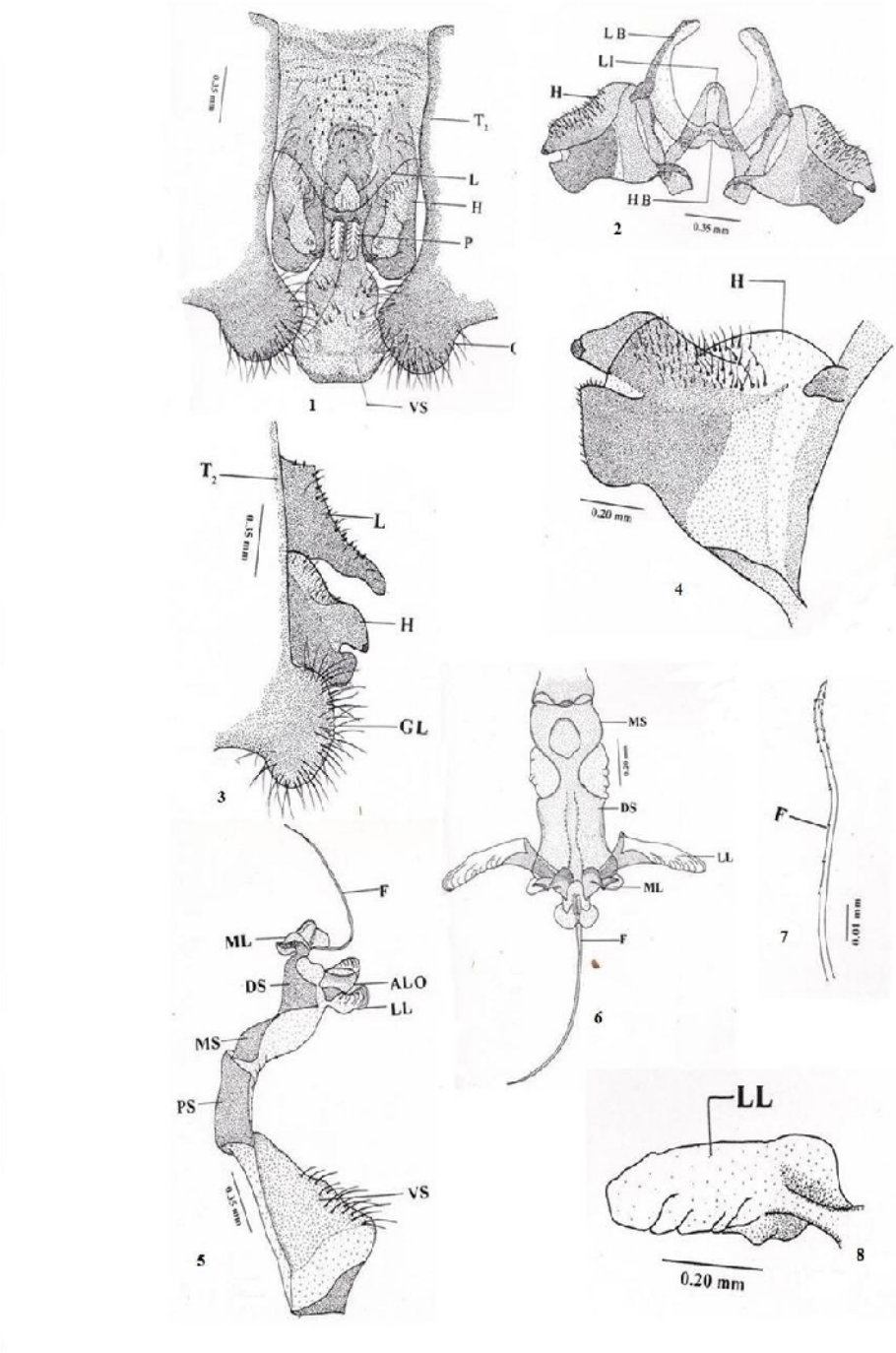
Material examined: Himachal Pradesh: Sirmour, Renuka Lake (400m), 2♂♂, 2♀♀, 01.V.2000.

Punjab: Ropar, Nangal, 4♂♂, 09.V.1998; Hoshiarpur, Talwara, 1♀, 01.V.1998.

Uttarakhand: Dehradun, Asan Barrage (400m), 1♂, 15.VII.1999; Chakrata Division, Nainbag, 1♂, 14.IX.1997.

Measurements:

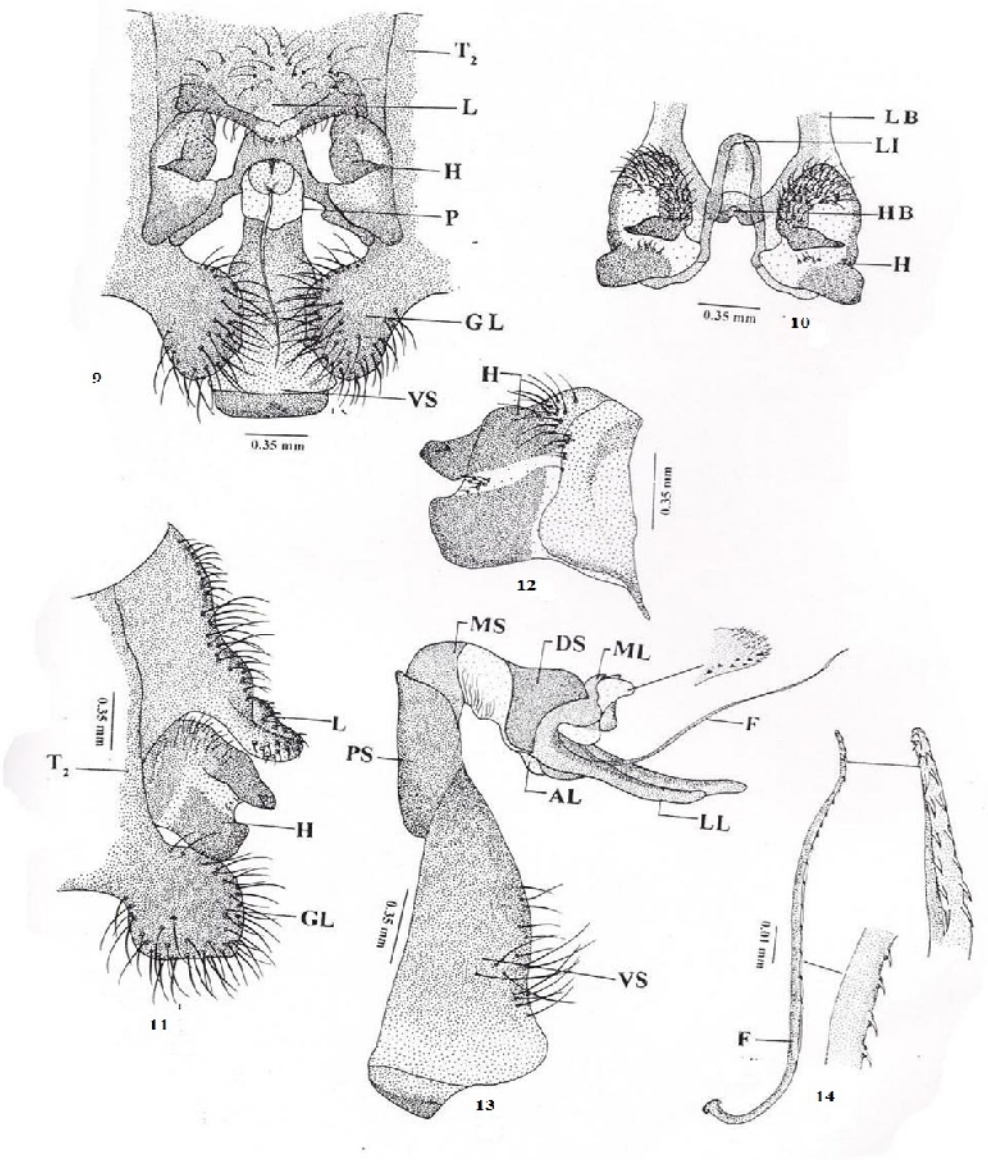
Fore wing	Hind wing	Abdomen
32-34 mm	31-33 mm	29-31 mm



Figures 1-8. Male genitalia of *Orthetrum brunneum brunneum* (Fonscolombe)
1. Male genitalia (Dorsal view); 2. Hamule & supporting framework; 3. Male genital (Lateral view); 4. Hamule (Lateral view); 5. Penis (Lateral view); 6. Distal segment of penis (Dorsal view); 7. Flagellum; 8. Lateral lobe

***Orthetrum glaucum* (Brauer) (Figs. 9-14)**
Brauer. 1865. *Verh. Zool. Bot. Ges. Wien*, **15**: 1012.
Diagnosis: The species under reference is a common dragonfly found in the foot hills and upto altitude of 1500m. It can be easily differentiated from the closely allied species, *luzonicum* (Brauer) and *taeniolatum* (Schneider) by its basal amber yellow colored marking in hind wings and in the shape of male genitalic structures. The male genitalia of *glaucum* (Brauer) has been studied in detail for the first time.

Male Genitalia: Lamina with its posterior free margin greatly thickened and produced posteriorly into a broad snout, apex of which bearing few microsetae, middorsum with a slight depression towards posterior border, furnished with numerous black setae and spines throughout; hamule furnished with short, but robust and strongly curled black hook, apex directed inwards and outwards at an right angle separated from broad and deeply sclerotized posterior base by comparatively deep and broad cleft; genital lobes black and small, constricted at base, apex very broadly triangular bordered with stiff, black, moderately long setae; vesicular spermalis elongated bearing several microsetae middorsally; penis with distal segment furnished distally with a pair of long and slender lateral lobes, truncated at apices; a pair of medial lobes; flagellum bearing proximally directed spines throughout except for a short base, spines becoming longer and thinner proximally; apical lobe large and highly inflatable, bearing broad overlapping tile like scales towards inner surface.



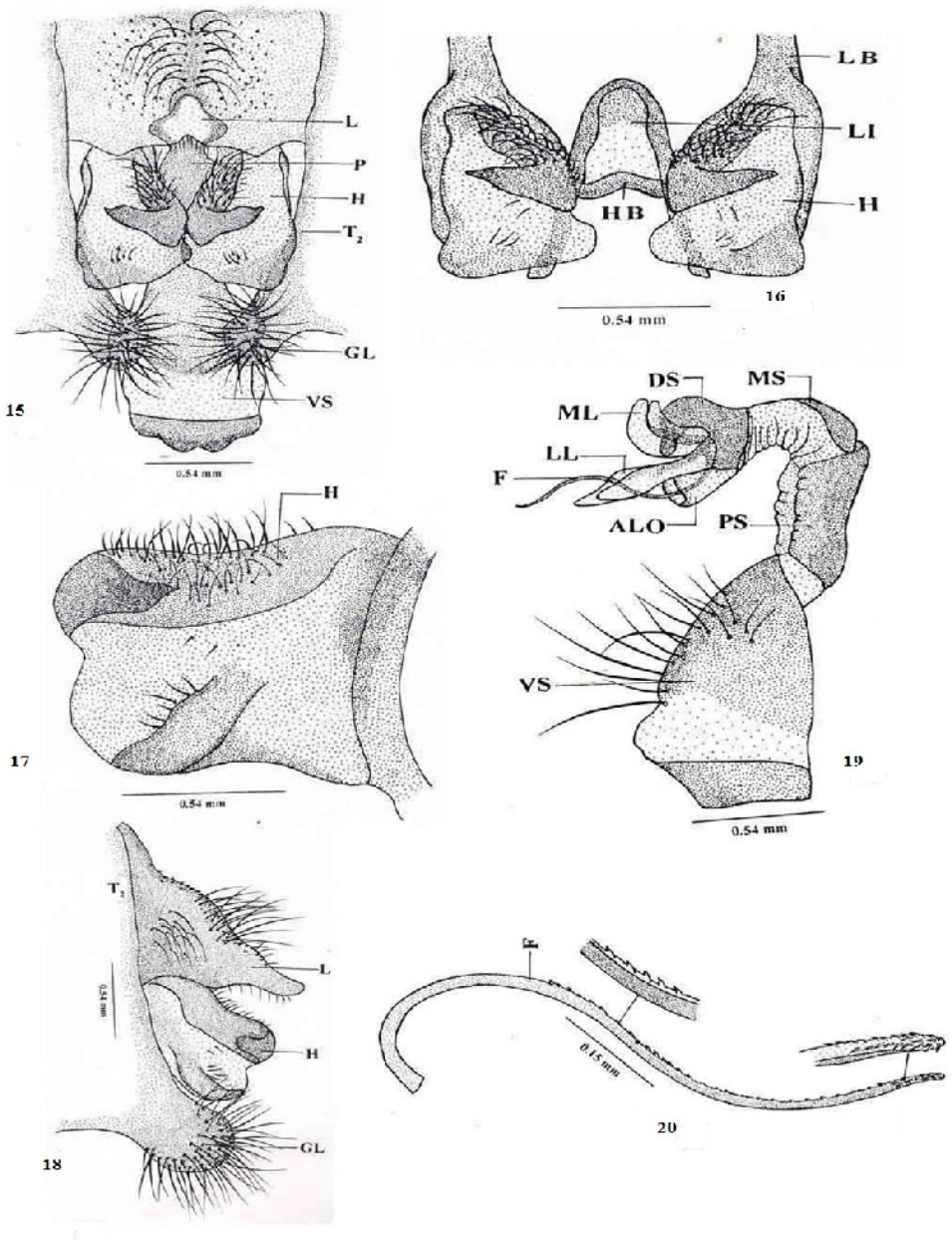
Figures 9-14. Male genitalia of *Orthetrum glaucum* (Brauer)
9. Male genitalia (Dorsal view); 10. Hamule & supporting framework; 11. Male genital (Lateral view); 12. Hamule (Lateral view); 13. Penis (Lateral view); 14. Flagellum

Material examined: Himachal Pradesh: Solan, Sadhupul (1700m), 1♂, 07.IX.1998, 2♂♂, 1♀, 17.X.1999; Renuka Lake (400m), 1♂, 1♀, 01.V.2000; Mandi (760m), 3♀♀, 13.VI.1998, Barot (2300m), 1♂, 15.VI.1998, Tikan (1220m), 2♂♂, 15.VI.1998.
Uttrakhand: Tehri Garhwal, Dhundprayag (795m), 3♂♂, 03.X.1998; Lakhamandal (1200m), 2♂♂, 13.IX.1997; Dehradun, Sahastradhara (450m), 1♂, 15.IX.1997, 4♂♂, 1♀, 12.VII.1999; Almora (1646m), 2♂♂, 27.VII.1999.

Measurements:

Fore wing	Hind wing	Abdomen
34-39 mm	33-38 mm	30-32 mm

***Orthetrum japonicum internum* Maclachlan (Figs. 15-20)**
Maclachlan. 1894. *Ann. Mag. Nat. Hist.*, **13**: 431.
Diagnosis: The present subspecies *japonicum internum* Maclachlan is found above an altitude of 1500m.



Figures 15-20. Male genitalia of *Orthetrum japonicum internum* MacLachlan
15. Male genitalia (Dorsal view); 16. Hamule & supporting framework; 17. Hamule (Lateral view); 18. Male genital (Lateral view); 19. Penis (Lateral view); 20. Flagellum

However, a single female representative of this species has been procured from Talwara. The color of the thorax and abdomen are distinct attributes to distinguish this subspecies from other allied taxa of the genus. The subspecies breeds in permanent water bodies. The male genitalia has been described and illustrated for the first time in present studies.

Male Genitalia: Lamina markedly projecting in lateral profile into a snout like structure, several setae and small spines scattered over dorsum; hamule with anterior hook acutely tapered into a prominent spine like structure at apices, latter pointing outwards and backwards; genital lobe small with apices globular, setosed with numerous long setae; vesicular spermalis elongated, flask shaped structure bearing several, slender macrosetae on its dorsum; penis with distal segment bearing a pair of well developed medial lobes and lateral lobes, latter long, slender for its basal half, slightly swollen medially, again tapering gradually towards apices, latter not acutely pointed; flagellum bearing proximally directed bristles for its distal 2/3, bristles more concentrated towards apex; apical lobe highly inflatable and spinose, folded like a scoop at rest.

Material examined:

Himachal Pradesh: Mandi, Barot (2300m), 3♂♂, 15.VI.1998; Chamba, Khajjiar (1851m), 4♂♂, 15.VI. 1999.

Punjab: Hoshiarpur, Talwara, 1♀, 01.V.1998.

Measurements:

Fore wing	Hind wing	Abdomen
33 mm	32mm	27mm

***Orthetrum pruinosum neglectum* (Rambur) (Figs. 21-27)**

Rambur. 1842. *Hist. Nat. Ins. Nevrop*., **1842**: 86.

Diagnosis: The subspecies *pruinosum neglectum* (Rambur) is one of the commonest dragonflies in the plains and also quite common in the hills upto an altitude of 1000- 1250m. Adults are seen perching on vegetation around larval habitats such as paddy fields, slow running streams and monsoon ponds. It can be easily differentiated from other species of genus *Orthetrum* Newman by its violet colored pruinescence.

The female of this subspecies is quite similar morphologically to that of *O. triangulare triangulare* (Selys) and differing from latter with respect to almost lacking basal yellow marking in hind wings and in the shape of subgenital plate.

Male Genitalia: Lamina markedly projecting in lateral profile, furnished with several long black setae on dorsum; hamule with anterior hook short and robust, apex slightly incurved, separated by a small and deep cleft from broad and truncated posterior base; genital lobes broadly constricted at base, apices flattened and rounded, coated with several moderately long, fine, dark brown setae; vesicular spermalis globular and elongated bearing distal fine macrosetae proximally on middorsum, size becoming smaller towards distal end; distal segment of penis with lateral lobes long and slender, flattened dorsoventrally, inner border close to base angulated, visible from dorsal view, apices rounded; flagellum long and slender, slightly swollen subapically finally ending in a rounded apex, furnished with proximally directed bristles nearly upto base, with stubby bristles distributed round apex; apical lobe large, highly inflatable structure, appearing bilobed in deflated stage, bearing 2 deeply sclerotized plates on either side basodorsally and bearing flattened overlapping tile like scales, latter with margins serrated.

Material examined:

Jammu & Kashmir: Jammu, 1♂, 24.IX.1998, Jakh, 5♂♂, 23.IX.1998, Kootah, 1♂, 24.IX.1998, Nagrota (1100m), 1♂, 24.IX.1998.

Himachal Pradesh: Mandi, Rewalsar (900m), 3♀♀, 14.VI.1998; Barot (2300m), 2♂♂, 15.VI.1998; Solan, Layughat (1300m), 1♂, 27.V.1999; Deragharat (1500m), 1♂, 2♀♀, 16.X.1999; Sadhupul (1700m), 3♂♂, 17.X.1999; Sirmour, Renuka Lake (400m), 3♂♂, 1♀, 22.X.1999.

Punjab: Patiala, Punjabi University, 1♂, 18.VII.1997, 6♂♂, 14.V.1998; Hoshiarpur, Talwara, 1♂, 01.X.1998; Gurdaspur, Sujanpur, 1♂, 03.VII.1998.

Uttarakhand: Gopeshwar (1000m), 1♂, 03.VII.2000, Nandaprayag (914m), 1♂, 03.VII.2000, Pipalkoti (1111m), 1♂, 27.V.2000; Tehrigarhwal, Nainbag (1000m), 1♂, 03.X.1998, Lakhamandal (1200m), 2♂♂, 13.IX.1997; Nainital, Haldwani, 1♂, 03.VIII.1999, Bhimtal (1900m), 1♂,01.VIII.1999, Naukuchiatal (1850m), 1♂, 01.VIII.1999.

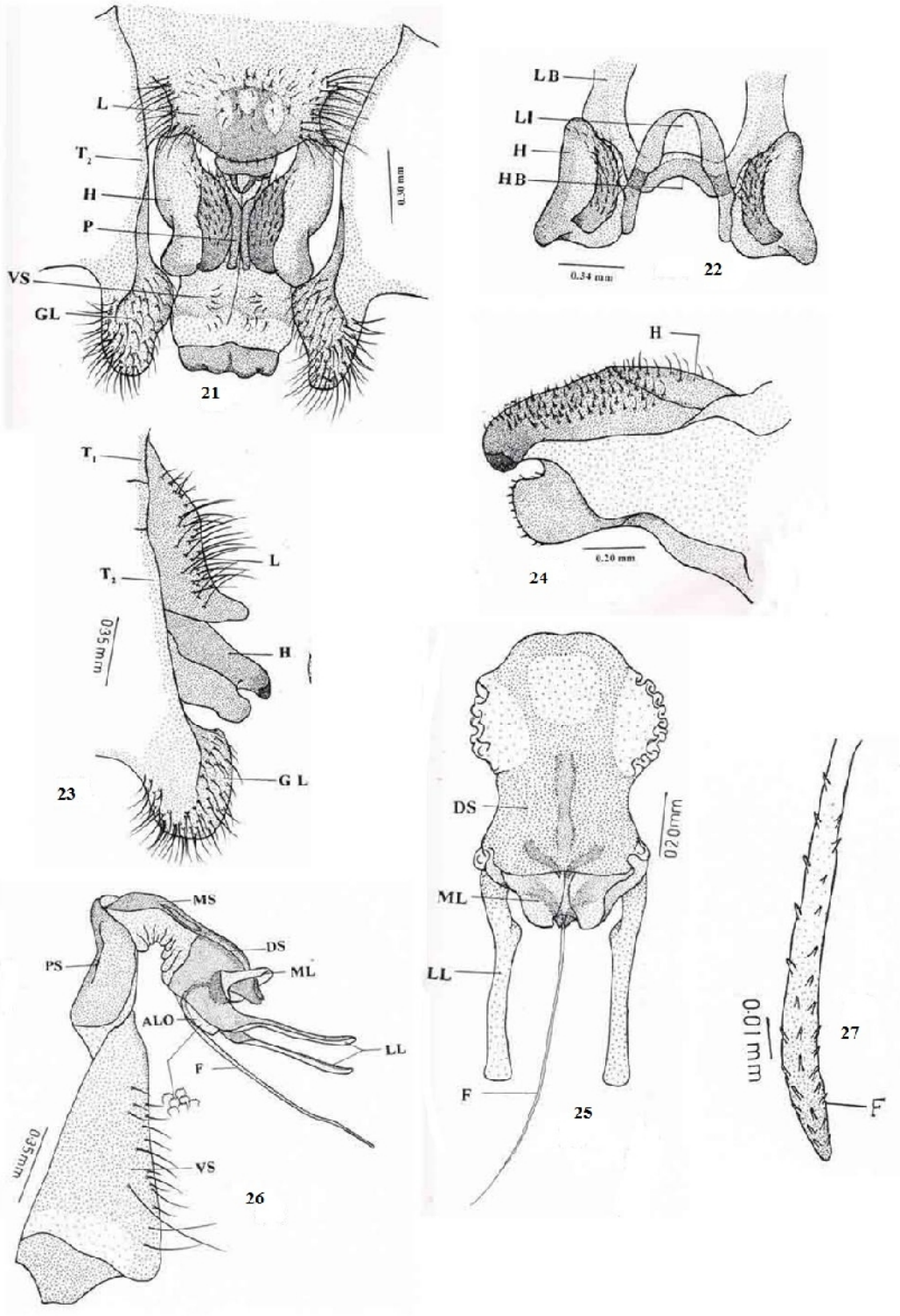
Measurements:

Fore wing	Hind wing	Abdomen
33-38 mm	31-36 mm	28-31 mm

***Orthetrum taeniolatum* (Schneider) (Figs. 28-33)**

Schneider. 1845. *Stett. Ent. Zeit*., **6**: 111.

Diagnosis: This species is a very common one in the dry zones and hot plains of India, even available upto an altitude of 1500m. It breeds in slow running marshy streams with mud and algal growth and also in the deep pools left by falling streams and is, therefore, most common just prior to the arrival of monsoon. Adults have been observed resting in the open rocky and sandy beds of the streams and rivers. The species taeniolatum (Schneider) resembles very closely with the subspecies *brunneum brunneum* (Fonscolombe) morphologically, however, differing from latter in being smaller in size and in the shape of the male and female genitalia. Teneral males are exactly similar to females in body color and markings.



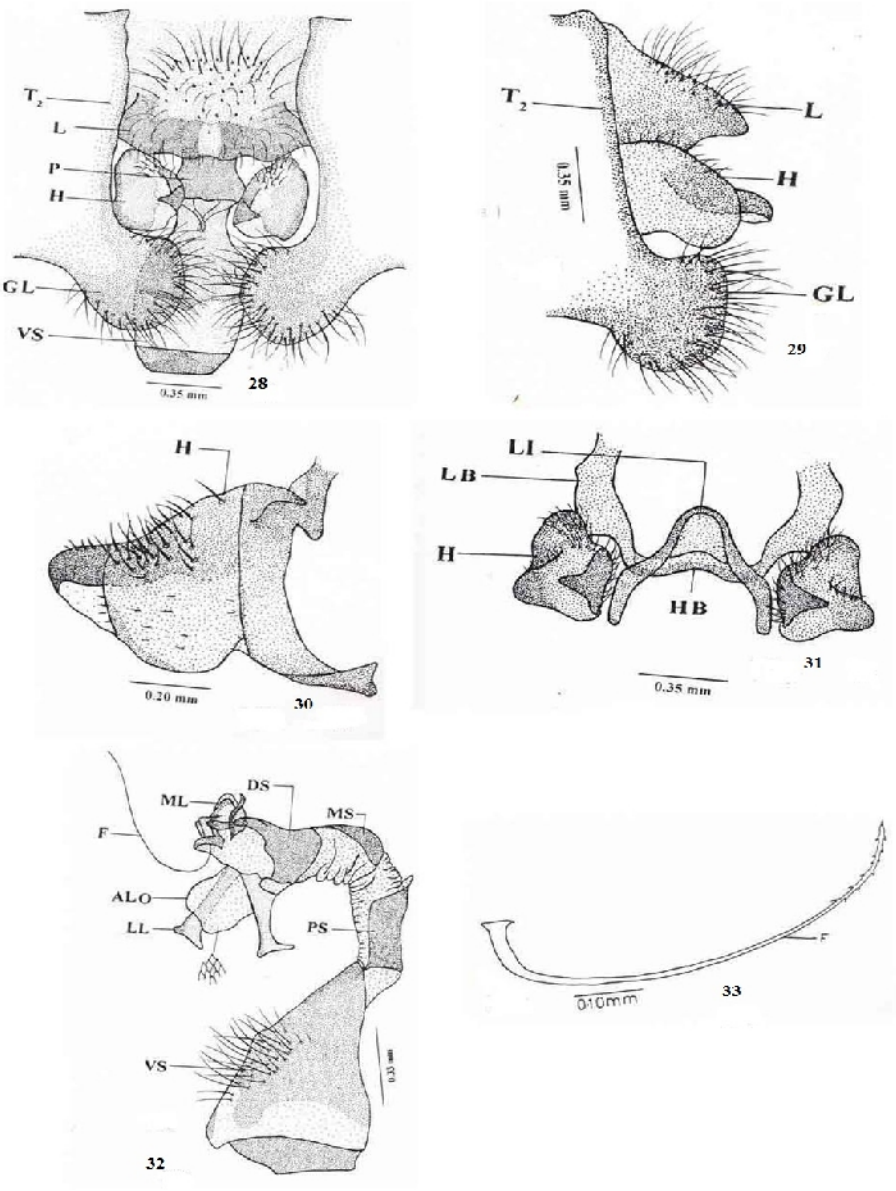
Figures 21-27. Male genitalia of *Orthetrum pruinosum neglectum* (Rambur)

21. Male genitalia (Dorsal view); 22. Hamule & supporting framework; 23. Male genital (Lateral view); 24. Hamule (Lateral view); 25. Distal segment of Penis (Dorsal view); 26. Penis (Lateral view); 27. Flagellum

Male Genitalia: Lamina projecting hood like, besotted dorsally with numerous moderately long stiff black setae and small black spines; hamule with well developed anterior hook, bearing numerous small and stiff setae, surpassing broadly truncated posterior base and separating from latter by small and deep cleft, apex of hook turned outwards and inwards; genital lobes black, apices broadly triangular pointing posteriorly, besotted with numerous slender setae; vesicular spermalis flask shaped bearing very long, slender setae on middorsum and subdorum; penis with distal segment bearing well developed medial lobes; lateral lobes rod shaped, outer border angulated near base, apices broadly truncated and slightly projecting posteriorly; flagellum with apex ending in a spine; approximately distal 1/3 furnished with acutely pointed, proximally directed spines; apical lobe highly inflatable, folded structure, bearing densely packed overlapping foliate scale like bristles.

Material examined:

Haryana: Nada Saheb, 1♂, 21.X.1997, Mansa Devi, 1♂, 20.IV.1987, Coll. M.S. Saini.



Figures 28-33. Male genitalia of *Orthetrum taeniolatum* (Schneider)

28. Male genitalia (Dorsal view); 29. Male genital (Lateral view); 30. Hamule (Lateral view); 31. Hamule & supporting framework; 32. Penis (Lateral view); 33. Flagellum

Himachal Pradesh: Sirmour, Renuka Lake (400m), 2♂♂, 1♀, 01.V.2000, Kedarpur (450m), 1♂, 03.V.2000; Bilaspur, KaulanWalan Toba (300m), 1♀, 12.VIII.1998; Kangra, Pong Reservoir (426m), 2♂♂, 18.VI.1999, Andretta (1200m), 1♀, 16.VI.1998; Solan, Sadhupul (1200m), 1♀, 17.X.1999.

Jammu & Kashmir: Jammu, Mansar Lake (1000m), 1♂, 24.IX.1998.

Uttrakhand: Dehradun, Dakpathar (450m), 4♂♂, 02.V.2000; Nainital, Bhimtal (1900m), 1♂, 01.VIII.1999, Naukuchiatal (1850m), 1♂, 1♀, 01.VIII.1999; Chakrata Division, Nainbag (1000m), 1♂, 14.IX.1997; Pauri, Chamdhar (910m), 1♂, 1♀, 03.X.1998.

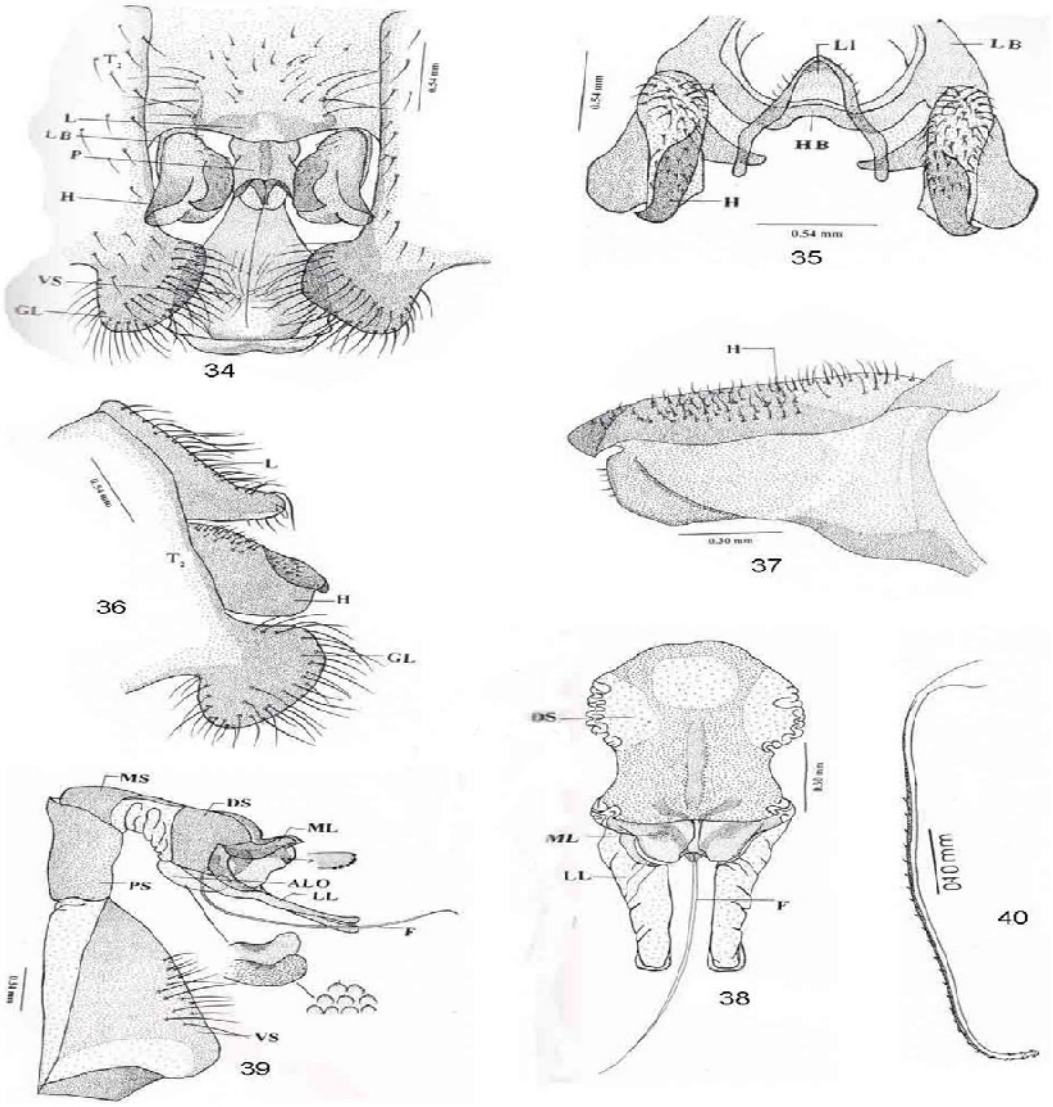
Measurements:

Fore wing	Hind wing	Abdomen
27-31 mm	26-30 mm	22-28 mm

***Orthetrum triangulare triangulare* (Selys) (Figs. 34-40)**

Selys. 1878. *Mitth. Mus. Dresden*., **1878**: 314.

Diagnosis: The subspecies under reference is a mountain species. It occurred along the entire Himalayas from Kashmir to Myanmar (Fraser, 1936). It has been observed that this subspecies breeds in brooks flowing through the streams and in road side drains.



Figures 34-40. Male genitalia of *Orthetrum triangulare triangulare* (Selys)

34. Male genitalia (Dorsal view); 35. Hamule & supporting framework; 36. Male genital (Lateral view); 37. Hamule (Lateral view); 38. Distal segment of Penis (Dorsal view); 39. Penis (Lateral view); 40. Flagellum

It is very robust and can be easily distinguished from other species of this genus by its black velvety color and black triangular marking at the base of hind wings. The teneral male resembles with female with black basal marking of hind wings replaced by amber yellow color.

Male Genitalia: Lamina projecting and hook like, furnished with numerous long, black and stiff setae on middorsum, microsetae present along posterior free margin; hamules furnished with short but robust strongly curled anterior hook, directed inwards, separated by a small cleft from broad posterior base, latter projecting outwards markedly when viewed from above, otherwise truncated from lateral view, whole structure coated with numerous microsetae; genital lobes small, apices globular on lower surface; vesicular spermalis elongated, roughly triangular in shape, bearing numerous moderately long black stiff setae both on mid and subdorsum; penis with distal segment bearing a pair of medial lobes; lateral lobes broad at base, then abruptly constricted, finally continued as long and slender tube like structure, measuring about 0.5 mm in length; flagellum with distal ¾ bearing very small proximally directed spines; apical lobe bilobed, deeply cleft upto base into 2 inflatable lobes, outer surface bearing spaced and numerous tile like scales.

Material examined:

Himachal Pradesh: Solan, Kandaghat (1500m), 1♀, 17.X.1999, Dergharat (1500m), 1♂, 17.X.1999. Sadhupul (1700m), 3♂♂, 17.X.1999; Mandi, Rewalsar (900m), 9♂♂, 3♀♀, 13.VI.1999, Jogindernagar (1220m), 1♀, 15.VI.1998, Kangra, Andretta (1200m), 5♂♂, 16.X.1998, 2♂♂, 1♀, 15.VI.1998, Lakkarmandi (2250m), 1♂, 14.VI.1999.

Uttarakhand: Nainital, Corbett National Park (450m), 2♂♂,18.VIII.1991, Sattal (1800m), 1♂, 29.VII.1999. Bhimtal (1900m), 1♂, 29.VII.1999, Chamdhar (910m), 3♂♂, 8♀♀, 03.X.1998, Kaudiyala (600m), 2♂♂, 05.X.1998; Chamoli, Pandukeshwar (1829m), 1♂, 27.V.2000, Garur Ganga (1327m), 1♂, 02.VII.2000, Mandal (2300m), 1♂, 04.X.1998; Dehradun, Sahastradhara (450m), 6♂♂, 15.IX.1997, 1♂, 21.VIII.1998, Mussourie (2005m), 1♀, 12.VII.1999.

Measurements:

Fore wing	Hind wing	Abdomen
32-34 mm	37-41 mm	29-33 mm

CONCLUSION

Kiany and Minaei (2009) while studying libellulid dragonflies from Fars Province, Italy given an account on five species of genus *Orthetrum* Newman including *O. brunneum* (Fonscolombei, 1837)and *O. taeniolatum* Schneider. The specimens studied by us showed same characters with few difference like in shape of genital lobes i.e. triangular in case of *taeniolatum* observed instead of rectangular. Later on, Degabriele (2013) also described six species of this genus from Maltese Island, highlighting the variation in lamina and hamule of male genitalia indifferent species.

The detailed examination of secondary male genitalic attributes of six species of genus *Orthetrum* Newman shows that genitalic attributes like lamina, hamules, vesicular spermalis and penis present a great deal of variation and are highly species specific. The structure of lamina and its setae are of quite good taxonomic significance and can be used to distinguish different species. Its arrangement generally varies from middorsum to apex region besides size varies from microsetae to moderately long and even to stiff spine like setae. All these secondary male genitalic attributes can be incorporated in detail diagnosis of studied species.

Abbreviations: AL- anterior lamina; ALO- apical lobe; DS- distal segment; F- flagellum; GL- genital lobe; H- hamule, HB- horizontal bar; L- lamina; LB- lateral bar; LL- lateral lobe; Ll- ligula; ML- medial lobe; MS- middle segment; P- penis; PS- proximal segment; T_2- second abdominal tergite; VS- vesicular spermalis.

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