



Revised phylogenetic analysis of Indian species of genus *Himalopsyche* Banks (Trichoptera: Spicipalpia: Rhyacophilidae)

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Abstract

Revised phylogenetic analysis was conducted for both the groups of the genus *Himalopsyche* (Trichoptera: Rhyacophilidae) based on characters of male genitalia. 17 characters representing 37 character states were used in the analysis. The results are discussed in terms of remarkable diversity of genitalic types in the males.

Keywords: Phylogenetic Analysis, Trichoptera, *Himalopsyche*, Genitalic types.

Introduction

The genus *Himalopsyche* originated in the Oriental region (Schmid, 1989). Over the globe this genus is represented by 48 species with 1 reported from Nearctic; 7 from East Palearctic and 40 from Oriental region (Morse, 2010). Based on *Rhyacophila tibetana* Martynov as its type species from Tibet, genus *Himalopsyche* was established and described by Banks (1940). On the basis of so many morphological affinities this genus is closely related to *Rhyacophila*, of which it seems to be a specialized off shoots. The diagnostic feature of genus *Himalopsyche* Banks include: metascutellum with spinifere warts and strongly spotted; venation similar to *Rhyacophila* except, veins R and M curve backward so that in forewings R₄ and R₅ are on each side of the apical wing point; discoidal cell open in both wings and the ventral abdominal process is absent. From the 40 species of Oriental region, around 18 species are from India and its adjoining areas (Morse, 2010) which are mainly contributed by Kimmins (1952), Martynov (1930, 1935, 1936), Morton (1900) and Schmid (1963, 1966) to the tune of 1, 3, 1 and 13 species respectively. Schmid (1966) divided genus *Himalopsyche* into two distinct groups i.e. Kuldschensis group and Tibetana group and to infer phylogeny of species of both groups some different characters were used.

When viewed from the economic point of view, larvae of this group are important and beneficial components of the trophic dynamics and energy flow in the lakes, rivers and streams they inhabit (Resh and Rosenberg, 1984). This group is considered the most useful and important aquatic organisms for monitoring climatic changes effects,

and are widely used in bio-monitoring surveys, many of which are now mandated by federal and municipal statutes in developed countries (Dohet 2002, Lenat 1993, Resh 1993, Resh and Unzicker 1975).

Materials and Methods

Species descriptions were derived primarily from literature contributed by Morton (1900), Martynov (1930, 1935, 1936), Kimmins (1952) and Schmid (1963, 1966). Revised phylogenetic analysis was carried with a computer program PAUP version 4.0, with more characters as compared to earlier study (Saini and Kaur, 2010), has been used to infer the phylogeny (Swofford, 2000). The characters used to infer phylogeny of groups of genus *Himalopsyche* Banks, 1940 were:

For Kuldschensis group

1. **Preanal appendage:** (0-absent, 1-present)
2. **Terminal part of inferior appendage:** (0-not globose, 1-globose)
3. **Anal sclerite in dorsal view:** (0-apically bifid, 1-apically entire)
4. **Median lobes of segment X:** (0-partly fused, 1-completely fused)
5. **Segment IX:** (0-does not form a roof over segment X; 1-forms a roof over segment X)
6. **Paramere:** (0-absent; 1-present)
7. **Paramere:** (0-without spines; 1-with strong spines, 2-absent)
8. **In side view anal sclerite:** (0-not pointed apically, 1-pointed apically)
9. **Paramere:** (0-simple, 1-trifid, 2-absent)
10. **Inferior appendage:** (0-uniarticulated, 1-biarticulated)

Table 1: Presence or absence data for ten characters for 10 species of the Kuldshensis group of genus *Himalopsyche* as used in the phylogenetic analysis ; *H. digitata*(Martynov,1935) is included as an outgroup.

Characters → Species ↓	1									
	1	2	3	4	5	6	7	8	9	0
<i>H.todma</i> Schmid,1963	1	0	0	0	0	1	1	0	1	0
<i>H. dolmasampa</i> Schmid,1963	1	0	1	0	0	1	1	1	1	0
<i>H. malenanda</i> Schmid,1963	1	0	1	1	1	1	1	1	1	0
<i>H. bhagirathi</i> Schmid,1963	1	1	1	0	1	1	0	0	1	0
<i>H. yongma</i> Schmid,1963	1	1	1	0	0	1	1	1	1	0
<i>H. yatrwalla</i> Schmid,1966	1	1	1	0	0	1	0	1	1	0
<i>H. lungma</i> Schmid,1963	1	1	1	0	0	0	2	1	2	0
<i>H. gyamo</i> Schmid,1963	1	1	1	0	0	0	2	0	2	0
<i>H. amitabha</i> Schmid,1966	0	0	1	0	0	1	1	0	0	0
<i>H. angnorbui</i> Schmid,1963	0	0	0	0	0	1	0	1	1	0
<i>H. digitata</i> (Martynov,1935) (outgroup)	1	0	1	0	0	-	-	1	-	1

For Tibetana group

- 1. Basal segment or basal part of inferior appendage:** (0-not constricted to a slender finger about midway, 1-constricted to a slender finger about midway)
- 2. Length of terminal segment or terminal part of inferior appendage:** (0-less as compared to basal, 1-almost equal to or longer than basal)
- 3. Terminal segment or terminal part of inferior appendage in side view:** (0-not visible, 1-visible)

- 4. Outer branch of lateral lobe of tergite X:** (0-not foliate, 1-foliate)
- 5. Preanal appendage:** (0-not bifid, 1-bifid)
- 6. Segment X in dorsal view:** (0-with pointed lobes, 1-with rounded lobes, 2-no distinction of lobes)
- 7. Inferior appendage:** (0-uniarticulated; 1-biarticulated)

Table 2: Presence or absence data for seven characters for 8 species of the Tibetana group of genus *Himalopsyche* as used in the phylogenetic analysis; *H. lungma* Schmid,1963 is included as an outgroup.

Species	Characters						
	1	2	3	4	5	6	7
<i>H. lepcha</i> Schmid, 1963	0	1	1	0	0	2	1
<i>H.horai</i> (Martynov,1936)	0	0	0	0	0	2	1
<i>H.lanceolata</i> (Morton,1900)	0	0	1	0	0	2	1
<i>H. tibetana</i> (Martynov,1930)	1	0	1	1	0	2	1
<i>H.biansata</i> Kimmins,1952	1	0	1	0	0	2	1
<i>H.maitreya</i> Schmid,1963	0	-	1	0	0	2	1
<i>H. digitata</i> (Martynov,1935)	0	1	1	0	1	0	1
<i>H.hierophylax</i> Schmid,1966	0	1	1	0	1	1	1
<i>H. lungma</i> Schmid,1963 (Outgroup)	0	1	1	0	0	1	0

Results

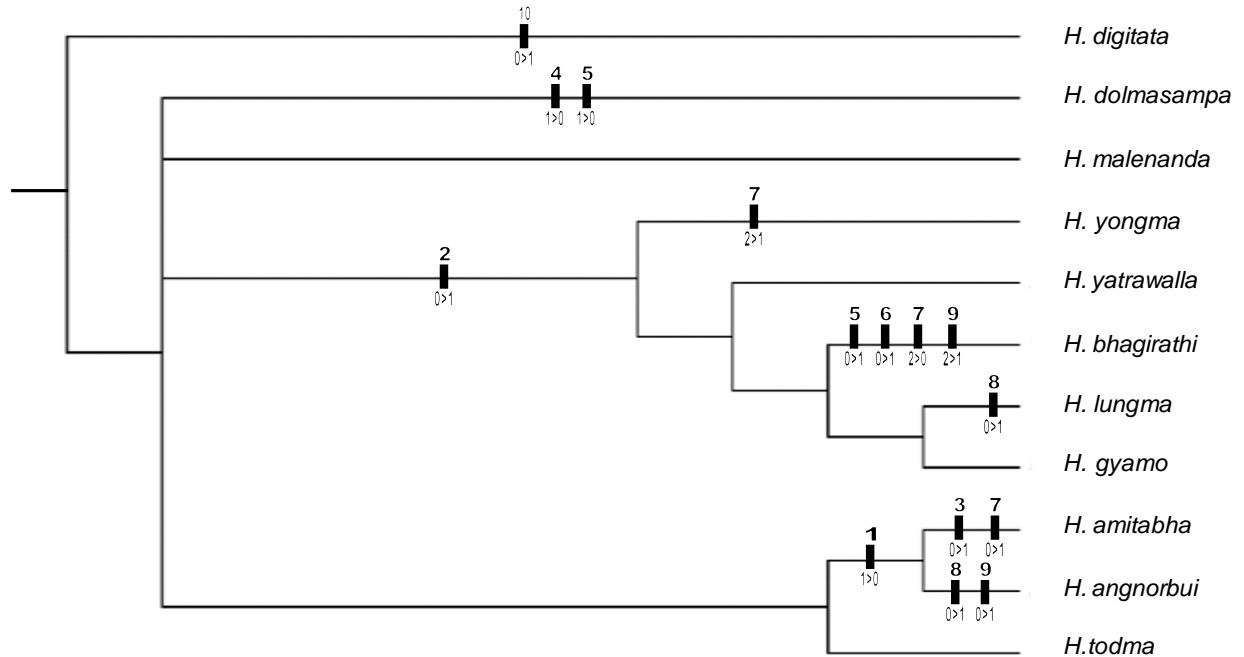


Fig. 1: Phylogenetic cladogram of 10 species of the Kuldshensis group of genus *Himalopsyche*. Character numbers are above the hashmarks; state changes are shown below with the respective primitive and derived conditions reported by a '>'. 28 trees were found using the computer program PAUP version 4.0, with consistency index (CI) of 0.66, a retention index (RI) of 0.60 and rescaled consistency index (RC) of 0.40.

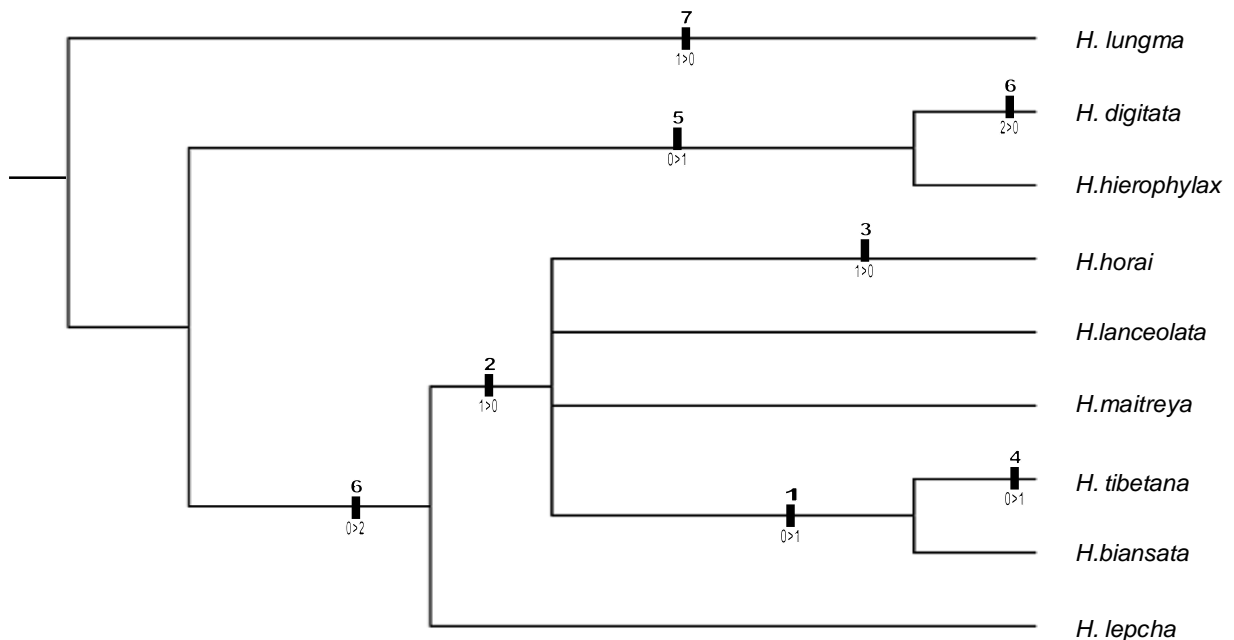


Fig. 2: Phylogenetic cladogram of 8 species of the Tibetana group of genus *Himalopsyche*. Character numbers are above the hashmarks; state changes are shown below with the respective primitive and derived conditions reported by a '>'. 3 trees were found using the computer program PAUP version 4.0, with consistency index (CI) of 1.00, a retention index (RI) of 1.00 and rescaled consistency index (RC) of 1.00.

Discussion

To analyze the phylogeny of both groups of genus *Himalopsyche* Banks 17 characters representing 37 character states were used. In fig. 1: outgroup taxon (*H. digitata*) got isolated from all species of Kuldshensis group on basis of biarticulation of inferior appendage (Character 10, state 1). *H. yongma*, *H. yatrwalla*, *H. bhagirathi*, *H. lungma* and *H. gyamo* showed synapomorphy due to (Character 2, state 1) terminal part of inferior appendage globose. *H. bhagirathi* can be distinguished from sister species *H. lungma* and *H. gyamo* on basis of characters 5, 6, 7 and 9. *H. amitabha*, *H. angnorbui* and *H. todma* formed cluster at the base of cladogram and sister species *H. amitabha* and *H. angnorbui* got isolated from *H. todma* on basis of absence of preanal appendage (Character 1, state 0).

In fig. 2 the outgroup (*H. lungma*) used to infer phylogeny in Tibetana group got separated from all species of Tibetana group by Character 7, state 0 i.e. unarticulated inferior appendage. *H. digitata* and *H. hierophylax* got isolated from all other species of this group on basis of bifidation of preanal appendage (Character 5, state 1) and all other species shared character 6. *H. lepcha* got separated from *H. horai*, *H. lanceolata*, *H. maitreya*, *H. tibetana* and *H. biansata* due to character 2 and sister species *H. tibetana* and *H. biansata* can be distinguished from each other on basis of outer branch of lateral lobe of tergite X foliate in *H. tibetana*. To conclude, this can be said that species of genus *Himalopsyche* Banks exhibit a remarkable diversity of genitalic types in the males.

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