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Cover: Watercolour illustrations—Striped Tiger *Danaus genutia*, Common Silverline *Cigaritis vulcanus*, Tamil Lacewing *Cethosia mahratta*. © Mayur Nandikar.

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ARTICLE

The present state of leech fauna (Annelida: Hirudinea) in Dal Lake, Jammu & Kashmir, India

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Abstract: Dal Lake supports a diverse group of fauna, including fishes, aquatic birds, zooplankton, and macrobenthic invertebrates. This study is the first taxonomic documentation of the leech fauna of Dal Lake. A total of nine leech taxa belonging to four families were identified and described: Glossiphoniidae – *Alboglossiphonia weberi*, *A. heteroclita*, *Glossiphonia complanata*, *Helobdella stagnalis*, *Hemiclepsis marginata asiatica*, and *Theromyzon* sp.; Erpobdellidae – *Erpobdella octoculata*; Hirudinidae – *Poecilobdella granulosa*; and Haemopidae – *Haemopis indicus*. Leeches play key roles in prey-predator dynamics and host-parasite relationships in freshwater ecosystems and as bioindicators of water pollution. This study provides essential data for taxonomic accounts and the diversity of leech fauna in Dal Lake.

Keywords: Freshwater ecosystem, annelid diversity, Himalaya, taxonomy, distribution, Glossiphoniidae, Erpobdellidae, Hirudinidae, Haemopidae.

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Author contributions: Conceptualization—Yahya Bakhtiyar, Niyaz Ali Khan. Methodology—Niyaz Ali Khan, Zahoor Ahmad Mir. Identification—Niyaz Ali Khan, Yahya Bakhtiyar, Zahoor Ahmad Mir. Writing—original draft preparation—Niyaz Ali Khan, Yahya Bakhtiyar. Review and editing— Yahya Bakhtiyar, Niyaz Ali Khan, Zahoor Ahmad Mir. Supervision—Yahya Bakhtiyar.

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INTRODUCTION

Leeches are annelids that coexist in freshwater ecosystems with molluscs, oligochaetes, and insect larvae and are found on every continent and in every ocean, except for terrestrial Antarctica (Sket & Trontelj 2008). Leeches prefer diverse environments and exhibit tolerance to extreme conditions such as variation in temperature, moisture, salinity, pressure, light, and pollution. They can be found in some wet soil on land and bottom substrates of freshwater, estuarine, and marine ecosystems (Phillips et al. 2020). Leeches are regarded as one of the most significant ecological indicators in freshwater ecosystems. Several aquatic species of leeches are important components in the aquatic food web at different trophic levels and also play a role in prey-predator and parasite-host relationships. Additionally, they are good bioindicators of water pollution, making them highly relevant from a scientific perspective (Bezmaternykh 2007; Romanova & Klimina 2010; Kaygorodova et al. 2014). Leeches serve as intermediary hosts for some larval stages of trematodes and are essential components of prey-predator and parasite-host relationships in aquatic environments (Pyrka et al. 2021). Around one-third of the total leech species have feeding mode as predators, while majority of leech species consume the blood of other invertebrates and vertebrates for their nutrition (Atkauskien & Rutkauskaitė-Sucilien 2022). Considering the taxonomic accounts, leeches have a circumoral and a posterior ventral sucker for attachment to substratum as well as a fixed number of segments (Wetzel 1992). They also lack setae but have a genital orifice and analogue jaws as diagnostic characters. One of the species, *Hirudo medicinalis*, of the class Hirudinea was traditionally used to treat people suffering from a variety of illnesses and medical ailments (Sig et al. 2017). In India, numerous new species of terrestrial and freshwater leeches have been documented over time beginning with the works of (Harding 1924; Baugh 1960 a,b; Soota & Ghosh 1977; Chandra 1982; Nesemann et al. 2004; Mandal 2004, 2013, 2015; Mandal et al. 2020a,b, 2022; Uttam & Langer 2021). There is a significant lack of comprehensive data regarding the distribution, biology, and ecology of many Indian leech species (Bhatia 1930, 1940; Baugh 1960 a,b; Ray 1980; Raut & Nandi 1985; Raut 1986; Raut & Saha 1987; Mandal et al. 2022). The existing literature regarding the leech fauna in the Kashmir valley's water bodies is mostly fragmented. Moreover, there are very few old records about the species composition of leeches from the waterbodies of Kashmir. In the 20th century, Moore (1924); Bhatia (1930, 1934, 1939, 1940), and Soota (1956) conducted studies on the leech fauna in Kashmir. Therefore, the literature reveals the need for fresh surveys and redescription of species regarding the leech fauna in freshwater bodies of the Kashmir valley. Considering the taxonomic concerns and lack of data available regarding the leech fauna, the present study has been conducted to explore the current leech fauna of Dal Lake.

MATERIALS AND METHODS

Study area

Dal Lake, one of the most cherished water bodies, in the Kashmir Himalaya, is situated in the urban area, providing numerous ecosystem services to the local population and boosting the urban economy. The lake is located between geographic coordinates 34.067–34.183 °N & 74.800–74.880 °E (Figure 1) covering a total catchment area of approximately 337 km^2. The lake has a surface area of 24 km^2, with 10.5 km^2 available as open water (Rashid et al. 2017). It is divided into four distinct basins: Hazratbal, Lokut Dal, Nigeen, and Gagribal (Amin et al. 2014). Dal Lake functions as an open drainage system, receiving water input from various streams and springs. Telbal Nallah and Botkol serve as the two main inflow channels, while smaller streams such as Meerakshah Nallah along with multiple springs originating from the lake bed and nearby mountains contribute to its water sources (Qadri & Yousuf 1980). The lake has two primary outlets, namely Nallah Amir Khan and Dalgate (Kumar et al. 2022). In the present study, the samples were collected from different locations within Dal Lake.

Methods applied for sampling, processing, and identification

Freshwater leeches were collected with standard bottom samplers (EU-WFD) used in different zones of Dal Lake, during the research work from January 2021 to December 2022. An Ekman's dredge was used to collect the mud samples in the deep water (limnetic zone) while the kick method was applied in shallow water (littoral zone) to collect samples from macrophytes, leaf packs, submerged logs, stones, concrete banks, and debris. Leech samples were carefully separated from extraneous material by handpicking tools and delivered as live samples in water- filled plastic jars (1l) to the Fish Biology and Limnology Research Laboratory, Department of Zoology, University of Kashmir. The

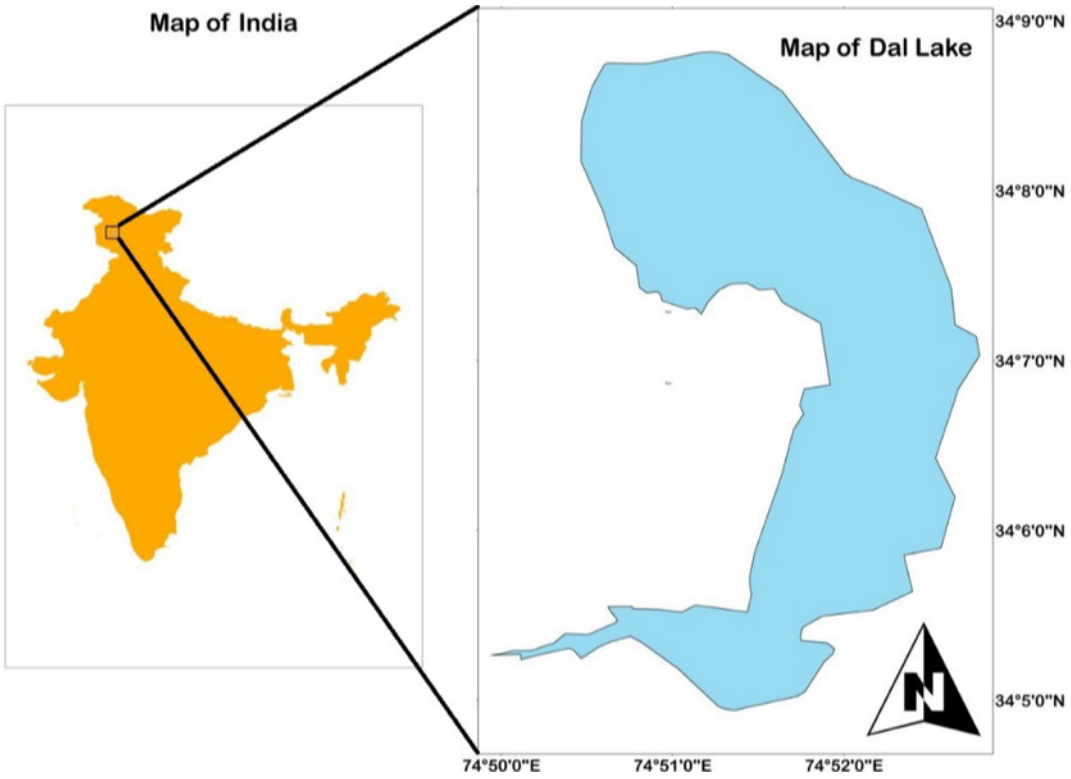

Figure 1. Geographical representation of Dal Lake from Kashmir Himalaya.

specimens were first narcotized using a gradient of low ethanol solutions and then preserved in 80% ethanol following the standard protocol of Kaygorodova & Bolbat (2020). Morphological analysis and photography were carried out using stereo zoom microscopes (Magnus MS 24 and LEICA S98) with a digital microscope camera (Magcam DC 10). Identification of species was done by using existing standard taxonomic keys of leeches (Klemm 1985; Chandra 1991; Nesemann et al. 2004; Mandal 2013).

RESULTS AND DISCUSSION

Family: Glossiphoniidae

***Alboglossiphonia weberi* (Linnaeus, 1761)**

Location: Telbal, 34.140°N & 74.863°E, 29.viii.2021, 13.ix.2022, coll. Niyaz Ali Khan.

Material examined: Image 1A–C; number of specimens observed = 15.

Diagnosis: The body is translucent ovate 10 mm in length; the dorsal surface is roughened by the presence of numerous tubercles (Image 1A); colour of the live specimen is somewhat yellowish-brown and on preservation in alcohol it becomes greenish white; it possesses a radial stripe of the same dark pigment which occurs upon the body (Image 1A); Presence of three pair of eyes one each on sixth, seventh and eighth ring (Image 1C); crop with six pairs of lateral diverticula**.**

Habitat: *Alboglossiphonia weberi* occurs in ponds, tanks, pools, lakes, slow-moving streams, and rivers. This species is found attached to the smooth surfaces of cobbles and pebbles in streams, and rivers.

Distribution: Widely distributed throughout India while outside India occurs in Pakistan, Nepal, Myanmar, and Sumatra (Chandra 1991).

***Glossiphonia complanata* (Linnaeus, 1758)**

Location: Telbal, 34.140°N & 74.863°E, 27.viii.2021, 15.iii.2022, coll. Niyaz Ali Khan; Nigeen, 34.123°N & 74.827°E, 27.viii.2021, coll. Niyaz Ali Khan; Ashai bagh, 34.114°N & 74.836°E, 27.viii.2021, 15.iii.2022, coll. Niyaz Ali Khan.

Material examined: Image 1D–H; n = 23.

Diagnosis: Body flat, leaf- shaped, dark brown and greenish in colour; the length is 14–25 mm; dorsal surface of the body is covered with six rows of papillae; dorsal surface has two paramedial dark lines interrupted by papilla which extends up to the middle portion of the body (Image 1D,G); two strips are also prominent on the

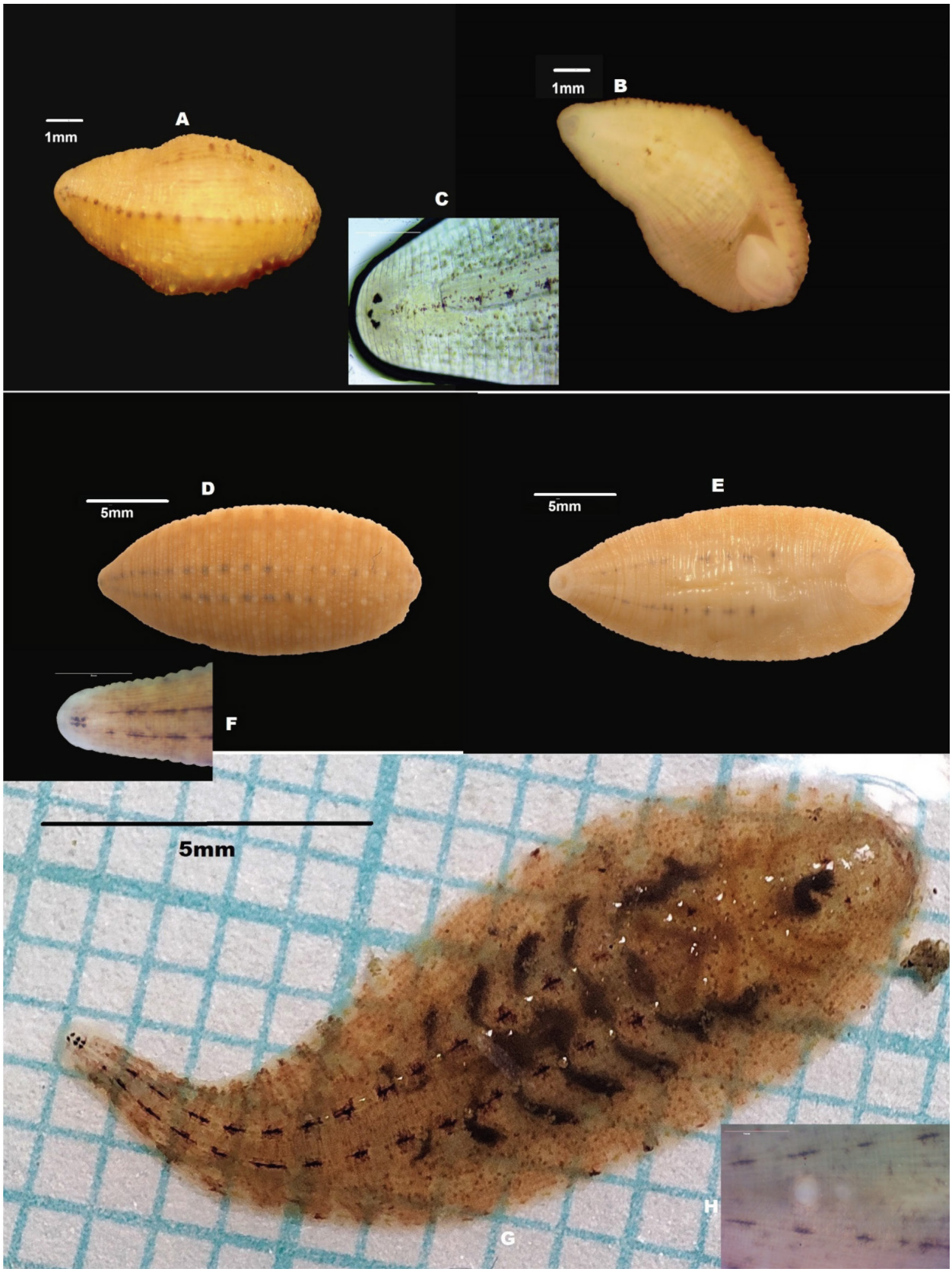

Image 1. Leech fauna of Dal Lake: A—dorsal view of *Alboglossiphonia weberi* | B—ventral side | C—anterior part showing the eyes pattern | D—dorsal side of *Glossiphonia complanata* | E—ventral side | F—anterior part of the body showing eye position | G—whole body of the live specimen | H—male and female gonopores. © Niyaz Ali Khan.

ventral side (Image 1E); three pair of eye spots located on the anterior somite's (Image 1F); posterior sucker is disk- like while the anterior sucker is triangular; six pair of crop caeca can be seen in freshly collected live specimens.

Habitat: *Glossiphonia complanata* was commonly found in stagnant water bodies and slow-flowing rivers characterized by plentiful vegetation and molluscs. Typically, this species was observed under submerged wood or stones.

Distribution: The species is widely distributed in India such as Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Karnataka, Madhya Pradesh, Bihar, West Bengal, Meghalaya, Manipur, and Odisha while outside India it has been reported from Pakistan, Nepal, Myanmar, Indonesia, Japan, U.S.A, and Europe (Chandra 1991; Mir et al. 2024).

***Alboglossiphonia heteroclita* (Linnaeus, 1761)**

Location: Telbal, 34.140°N & 74.863°E, 29.iii.2021, coll. Niyaz Ali Khan; Nigeen, 34.123°N & 74.827°E, 10.viii.2021, coll. Niyaz Ali Khan.

Material examined: Image 2A–C; n = 23.

Diagnosis: Small, flat, and ovate leeches are generally yellowish translucent in live specimens; the head region is bulbous consisting of three pair of eyes of which the first pair of eyes lie close to each other and are the smallest ones as compared to the other two pairs (Image 2C); second and third pair of eyes are widely separated but the components lie near together giving approximately a triangular shape (Image 2C); three pair of eyes generally lie in rings five , seven and eight respectively; one median line of dark black spots on every third annulus and numerous small spots on the dorsal surface (Image 2A); dorsal and ventral surface of the body is smooth and without papillae (Image 2A,B).

Habitat: *Alboglossiphonia heteroclita* is found in lakes and ponds attached to submerged articles and are parasitic mainly on molluscs (Chandra 1991).

Distribution: *Alboglossiphonia heteroclita* is a species with a Holarctic distribution, found in central and western Europe (Nesemann & Neubert 1999; Bielecki et al. 2011). It has also been recorded in Lithuania while in India, the species occur in Rajasthan and Bihar (Chandra 1991).

***Helobdella stagnalis* (Linnaeus, 1758)**

Location: Telbal, 34.140°N & 74.863°E, 2.iv.2021, 22.x.2022, coll. Niyaz Ali Khan.

Material examined: Image 3A–C; n = 7.

Diagnosis: Small flat, leaf- shaped ceramic white when alive and pale white on preservation with numerous tiny spots on the dorsal surface; an anterior region with a single pair of eyespots and a chitinous scute (nuchal plate) is visible on the dorsum (Image 3A,C); smooth body surface without any papillae.

Habitat: *Helobdella stagnalis* is found in stagnant water bodies in association with molluscs. Adults show parental care where young ones are attached to the ventral side of the body (Image 3B).

Distribution: In India, the species occur in Himachal Pradesh and Jammu & Kashmir (Mir et al. 2024) while outside India it has been reported from the USA, Lithuania (Zettler & Daunys 2007), Canada, and Paraguay (Chandra 1991).

***Theromyzon* sp. Philippi, 1867**

Location: Telbal, 34.140°N & 74.863°E, 22.x.2021, coll. Niyaz Ali Khan.

Material examined: Image 3D– J; n = 33.

Diagnosis: Large dorsoventrally flattened olive green or brownish in colour (Image 3G); preserved specimens are brownish due to decolouration (Image 3D); six rows of yellow spots on the dorsal side of the body; ventral side possesses a large number of small papillae; suckers are small and weak in comparisons to the body size; four pair of eyespots arranged straight in head region; first pair of eyespots lie close to each other and second, third and fourth pair of eyes widely separated in ascending order (Image 3J); four annuli between male and female gonopore (Image 3F); young ones appear green in colour and are found attached to the ventral side of the parent body (Image 3H).

Habitat: *Theromyzon* sp. was found mainly in the stagnant water with the presence of aquatic birds. They are found attached to the submerged articles, under stones and wood. Adult shows parental care where around 100 young ones are attached to the ventral side of the body (Image 3H).

Distribution: *Theromyzon* sp. has been reported in many states of India (Chandra 1982) while outside India, the species occurs in European, American, and African countries (Davies et al. 2008).

***Hemiclepsis marginata asiatica* (Moore, 1924)**

Location: Telbal, 34.140°N & 74.863°E, 27.viii. 2021, coll. Niyaz Ali Khan.

Material examined: Image 4A–D; n = 11.

Diagnosis: The leech is commonly known as the disproportioned- eyed leech; two pairs of eyes are present, with the anterior pair being extremely small (Image 4C); the first pair of eyes are closely positioned

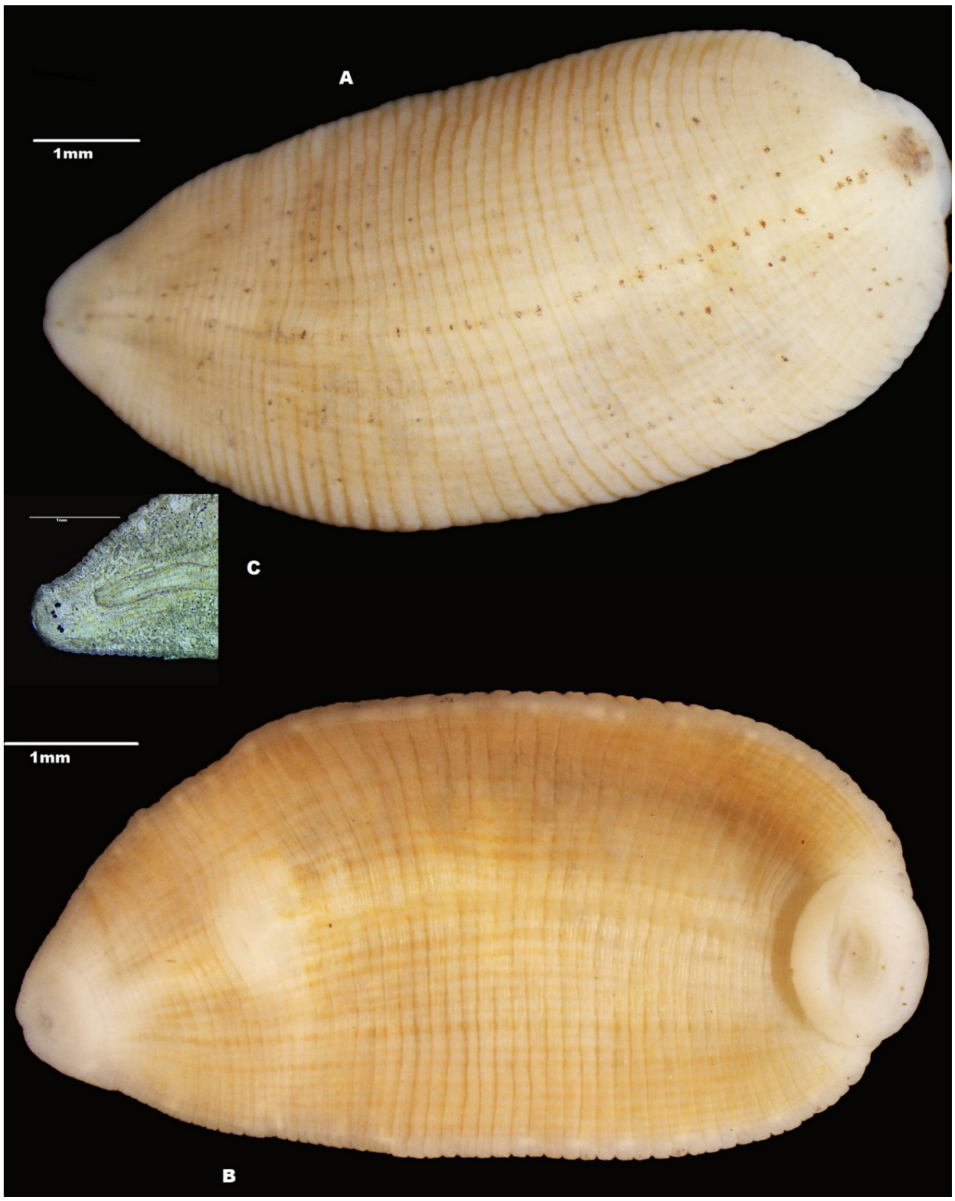

Image 2. Leech fauna of Dal Lake: A—dorsal view of *Alboglossiphonia heteroclita* | B—ventral side | C—anterior part showing the eyes pattern. © Niyaz Ali Khan.

and very tiny (Image 4C); eyes are typically located just ahead of the more noticeable and widely spaced posterior pair of eyes; leech is translucent in appearance; size is approximately 16 mm in length and 6 mm in width; the head region is enlarged and differentiated from the rest of the body; leech exhibits a reddish-brown colour in natural environment and whitish on preservation; dorsal surface with broken transverse stripes in a pale-yellow (Image 4A); crop region contains 11 pairs of lateral diverticula.

Habitat: *Hemiclepsis marginata asiatica* is common in shallow margins of lakes and ponds overgrown by vegetation. Found attached to submerged articles, plants, stones, and wood as microhabitats.

Distribution: Mostly occurs in Jammu & Kashmir and Himachal Pradesh states of India (Chandra 1991; Mir et al. 2024).

Family: Erpobdellidae

***Erpobdella octoculata* (Linnaeus, 1758)**

Location: Telbal, 34.140°N & 74.863°E, 2.i.2021, coll. Niyaz Ali Khan; Nigeen, 34.123°N & 74.827°E, 2.i.2021, coll. Niyaz Ali Khan; Ashai bagh, 34.114°N & 74.836°E, 17.viii.2021, 27.viii.2022, coll. Niyaz Ali Khan.

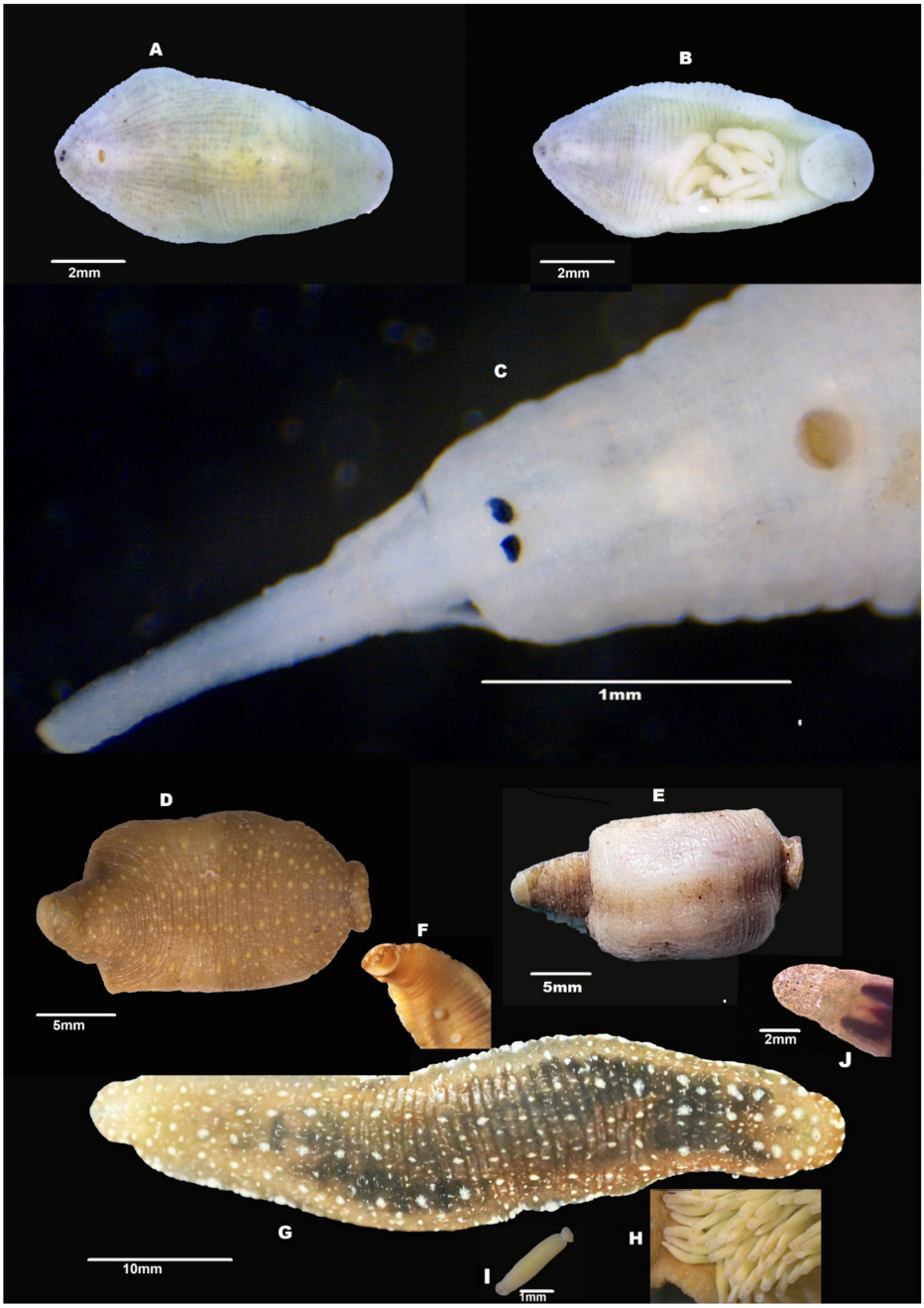

Image 3. Leech fauna of Dal Lake: A—dorsal view of *Helobdella stagnalis* | B—young ones attached to the ventral side | C—anterior part showing the single pair of eyes and nuchal scute | (D)—dorsal side of the preserved specimen *Theromyzon* sp. | E—ventral side of preserved specimen | F—position of male and female gonopores| G— full body of live specimen | H— young ones attached to the ventral side of adult body | I—juvenile | J—anterior part showing the four pairs of eyes. © Niyaz Ali Khan.

Material examined: Image 4E–H; n = 43.

Diagnosis: These leeches vary in size, ranging from medium to large, and also exhibit a variety of colours; possess a relatively robust body form compared to other species in the same family, with a nearly uniform shape that tapers anteriorly to the clitellum; head is relatively small in proportion (Image 4E); typically, they have four pairs of eyes; first pair located on segment II; second pair at the furrow between segments II and III; third and fourth pairs situated on the sides of the buccal ring on segment IV (Image 4F); breeding individuals display a well-defined clitellum; gonopores are separated by approximately two and a half annuli (Image 4H).

Habitat: Most common leech species found in

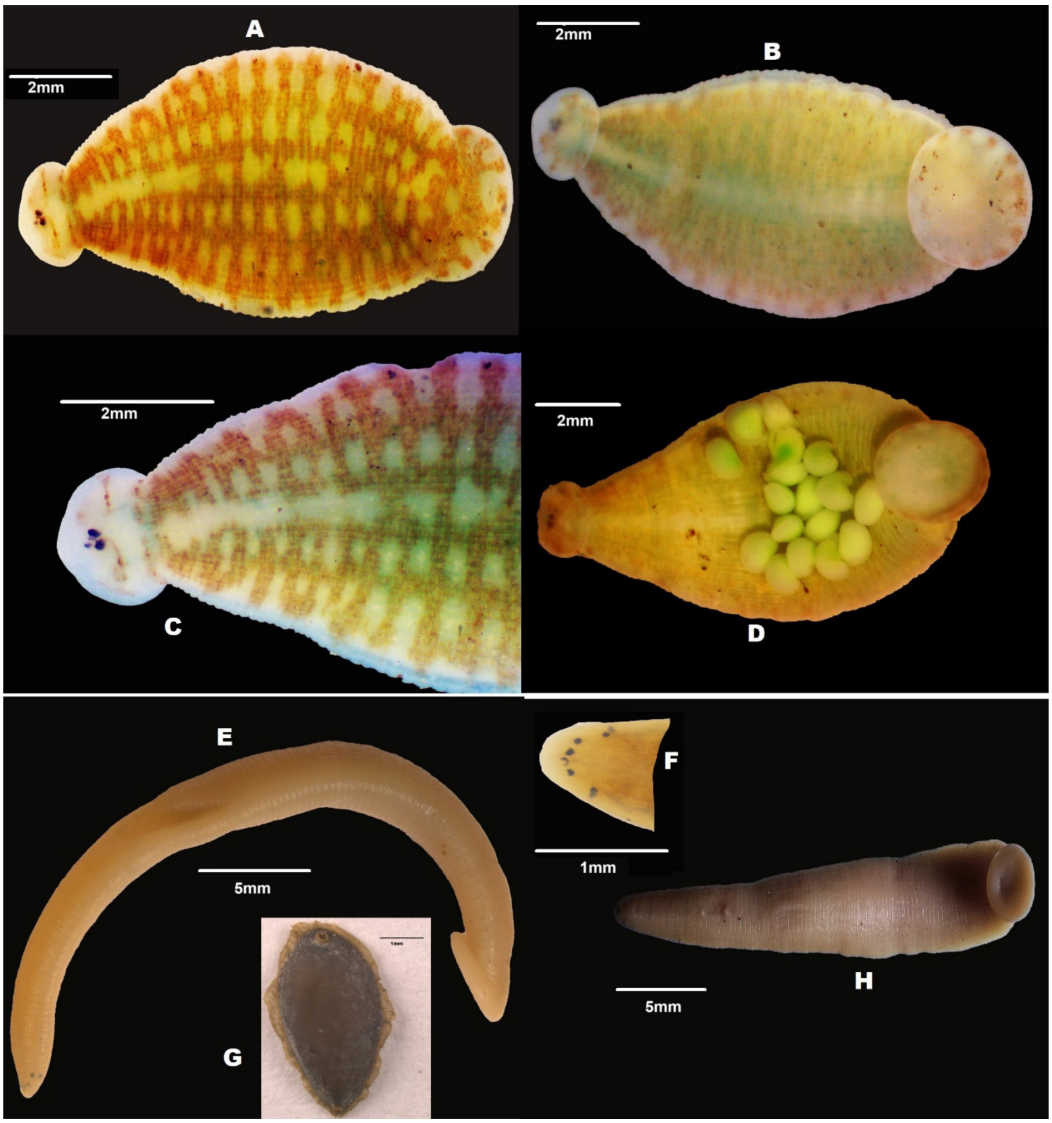

Image 4. Leech fauna of Dal Lake: A—dorsal view of *Hemiclepsis marginata asiatica* | B—ventral side | C—anterior part showing the eyes | D—eggs attached to the ventral side of adult | E—dorsolateral view of *Erpobdella octoculata* | F—anterior part showing the four pair of eyespots | G—cocoon | H—ventral side. © Niyaz Ali Khan.

both lentic and lotic water bodies attached to stones, submerged articles, and leaves of aquatic plants.

Distribution: In India, occurs mostly in Jammu and Kashmir (Mir et al. 2024) while outside India, it occurs in Lahore (Pakistan), Palestine, and Europe (Chandra 1991).

Family: Hirudinidae

***Poecilobdella granulosa* (Savigny, 1826)**

Location: Nigeen, 34.123°N & 74.827°E, 10.ix.2021, coll. Niyaz Ali Khan.

Material examined: Image 5(A–D); n = 10.

Diagnosis: The average adult body is about 70 mm long; dark greenish-brown in colour, and has a dorsal surface covered in geometrically structured black patterns and squares (Image 5A); the median line is always dark; the body is solid and has a very rough surface with the abundance of big papillae; typical five sets of eyes present (Image 5C).

Habitat: *Poecilobdella granulosa* was found in stagnant water or nearly stagnant water bodies with muddy bottoms, vegetation, and water with organic-rich material.

Distribution: In India, occurs in Punjab, Himachal Pradesh, Uttar Pradesh, Gujrat, Maharashtra, Madhya Pradesh, Tamil Nadu (Chandra 1983), Jammu & Kashmir, Kerala, Manipur, Odisha, Rajasthan, Sikkim, Uttarakhand, and West Bengal (Ahmed 2021) while outside India, occurs in Sri Lanka, Nepal, and Myanmar.

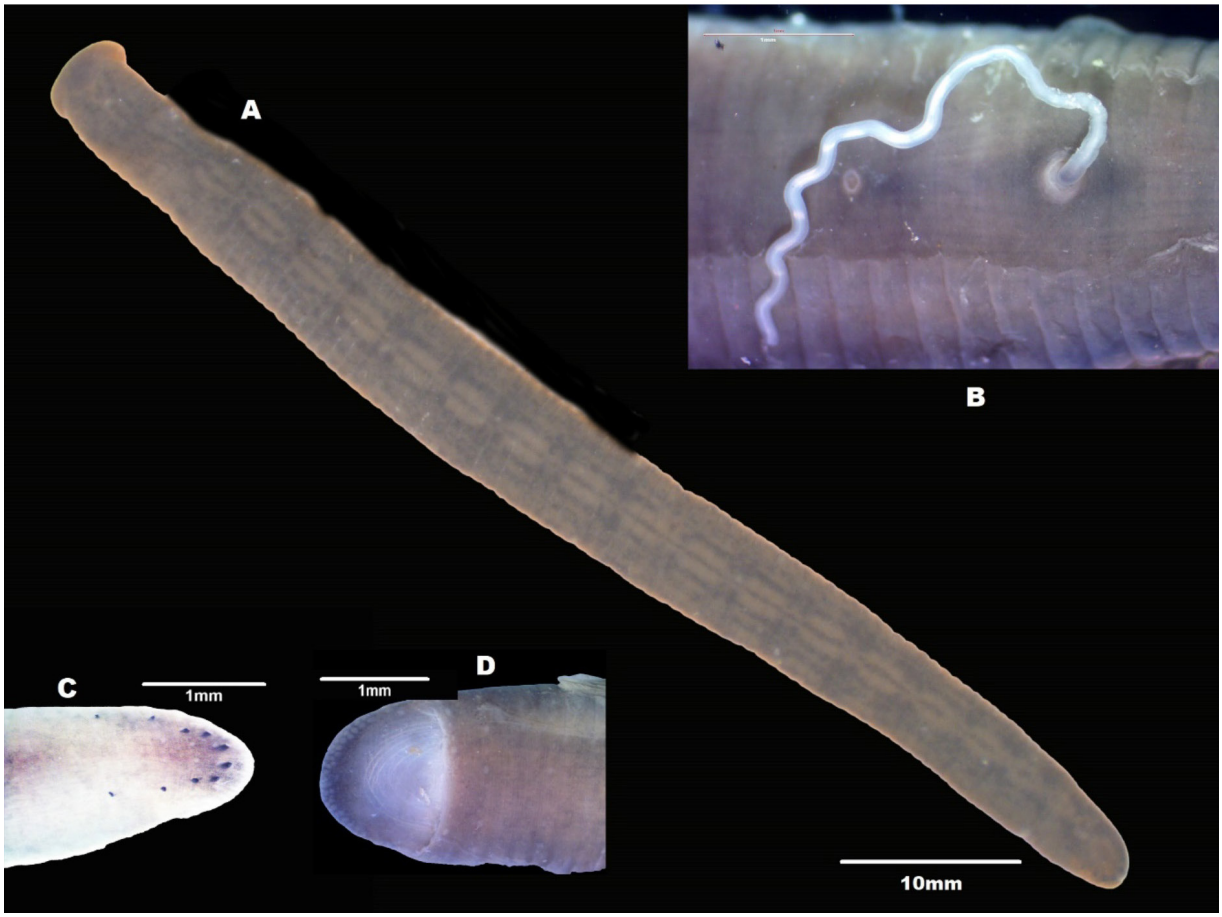

Image 5. Leech fauna of Dal Lake: A—dorsal view of *Poecilobdella granulosa* | B—position of male and female gonopores | C—anterior part showing five pair of eyespots | D—mouth position. © Niyaz Ali Khan.

Table 1. The systematic list of leech species collected from Dal Lake.

Phylum	Class	Order	Family	Genus/Species	Authority	Common Name
Annelida	Hirudinea	Rhynchobdellida	Glossiphoniidae	*Alboglossiphonia weberi*	(Blanchard, 1897)	Proboscis-bearing Leech
				Glossiphonia complanata	(Linnaeus, 1758)	Proboscis-bearing Leech
				Helobdella stagnalis	(Linnaeus, 1758)	Proboscis-bearing Leech
				Theromyzon sp.	Philippi, 1867	Duck Leech
				Alboglossiphonia hetroclita	(Linnaeus, 1761)	Small Snail Leech
				Hemiclepsis marginata asiatica	(Moore, 1924)	Disproportioned-eyed leech
		Archynchobdellida	Erpobdellidae	*Erpobdella octoculata*	(Linnaeus, 1758)	Worm Leech
			Hirudinidae	*Poecilobdella granulosa*	(Savigny, 1826)	Cattle Leech
			Haemopidae	*Haemopis indicus*	(Bhatia, 1940)	Blood-sucking Leech

Family: Haemopidae

***Haemopis indicus* Bhatia, 1940**

Location: Ashai Bagh, 34.114°N & 74.836°E, 3.iii.2022, coll. Niyaz Ali Khan.

Material examined: Image 6A–C; n = 6.

Diagnosis: The body of the leech is characterized by its remarkably soft and flabby texture; it appears thick for the majority of its length; gradually tapering towards both ends; the ventral surface is relatively flat; the dorsal surface is broadly arched; the posterior sucker is small and lacks strength; leech displays a dark colouration without any distinct markings (Image 6A);

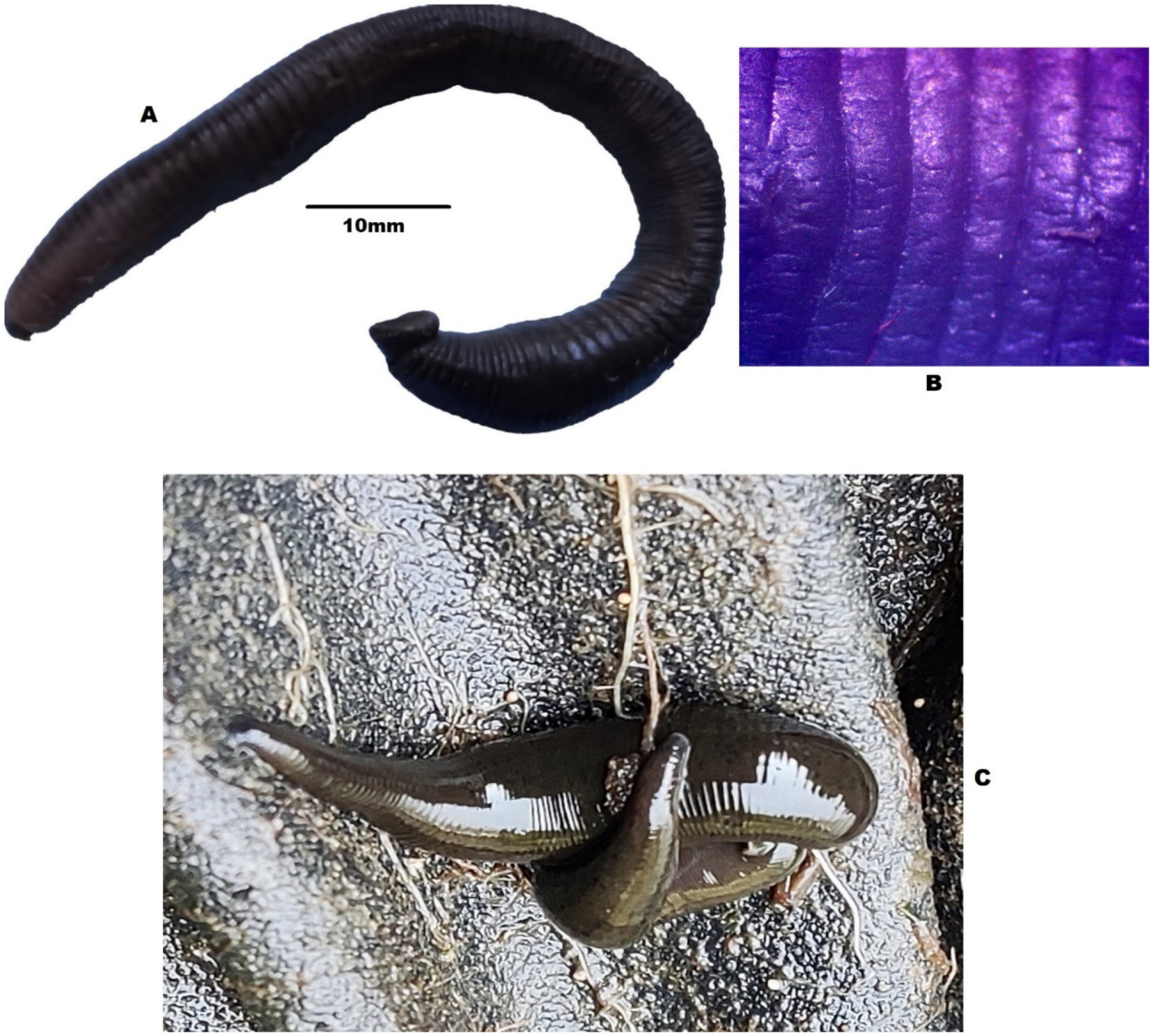

Image 6. Leech fauna of Dal Lake: A—dorsolateral view of *Haemopis indicus* | B—position of male and female gonopores | C—dorsal view of live specimens. © Niyaz Ali Khan.

the arrangement of the five pairs of eyes follows the typical pattern; fourth eye separated from the third by a single annulus; fifth eye separated from the fourth by two annuli; gonopores are separated by approximately five and a half annuli (Image 6B).

Habitat: *Haemopis indicus* also known as barrowing leech was mainly found attached to submerged articles in stagnant water bodies or nearly stagnant water rich in organic matter and vegetation.

Distribution: The species has been mostly reported in Jammu and Kashmir, India (Chandra 1991; Mir et al. 2024).

During the present study, a total of nine taxa belonging to the class Hirudinea were identified on the basis of morphological characteristics like colour, size and shape, number and position of eyes, papillation, number of annulations, and position of male and female gonopores (Table 1). The taxa identified were *Alboglossiphonia weberi*, *A. heteroclita*, *Glossiphonia complanata*, *Helobdella stagnalis*, *Hemiclepsis marginata asiatica*, *Theromyzon* sp., *Erpobdella octoculata*, *Poecilobdella granulosa*, and *Haemopis indicus*. As per earlier record, Bhatia (1939) described and reported *Theromyzon mathai* from Kashmir which is morphologically similar to *Theromyzon* sp. collected during the current study except the latter possesses four annuli between male and female gonopore instead of three annuli. The collected specimen resembles more to the European

species *Theromyzon tessulatum* but it still needs confirmation based on the comparative studies with the closer species of *Theromyzon* sp. The paper presents the first photographic documentation of aquatic leeches occurring in Dal Lake. This study redescribed the leech species that were previously recorded in the valley. In contrast to the previous species found in the valley, most of the species are found in Dal Lake and many other species have no records. Based on existing records, there have been a total of 32 known leech species documented in Jammu and Kashmir (Mandal et al. 2022). To verify the species richness and specifically identify any new species, it is necessary to conduct proper surveys in the water bodies of the valley to overcome the fragmented and scanty record of the previous two decades. The current knowledge of leech diversity in Kashmir is far from being a comprehensive study and needs detailed surveys for complete documentation.

CONCLUSION

The present study provides knowledge about the taxonomic description, habitat, and distribution of freshwater leech fauna from the Kashmir Himalaya. A total of nine species belonging to four families of class Hirudinea were recorded and documented. Six species were reported from the family Glossiphonidae while single species were reported each from the families Hirudinidae, Erpodellidae, and Haemopidae. As per the literature and present status, the habitat of leech fauna has been disturbed due to growing poor water quality and shrinkage of freshwater water bodies. The present study has been conducted to address the taxonomic record of leech fauna in Dal Lake of Kashmir Himalaya.

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