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continued on the back inside cover

**Cover: Orange Oakleaf *Kallima inachus* with colour pencils and watercolor wash by Elakshi Mahika Molur adapted from a workshop by Lenin Raj.**

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COMMUNICATION

# Sacred river of Pune: boon or bane for the diversity of aquatic beetles (Insecta: Coleoptera)

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**Abstract:** Aquatic beetles are potential indicators of freshwater ecosystem and play an important role in food web and nutrient cycling. Parameters like pH, temperature, conductivity, total dissolved solids, salinity, and dissolved oxygen, are important water quality parameters. The present study is focused on the diversity of aquatic beetles and assessing water quality parameters of the sacred Indrayani River from various sites namely Valvan, Kamshet, Warangwadi, Begadewadi, Moshigaon, Alandi, Dhanore, and Tulapur. A total of 94 examples of aquatic beetles belonging to 31 species under 19 genera and four families from Indrayani River were recorded along with water quality parameters.

**Keywords:** Abiotic factors, checklist, Dytiscidae, fauna, Gyrinidae, habitat, Hydrophilidae, Maharashtra, Noteridae.

**Editor:** Anonymity requested.

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**Competing interests:** The authors declare no competing interests.

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**Author contributions:** All authors contributed equally to the paper.

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## INTRODUCTION

Aquatic insects are integral part of aquatic ecosystems, representing essential components of biodiversity and play a profoundly significant role in recycling nutrients and form a crucial part of the natural food web in these environments (Subramanian & Shivaramakrishnan 2007). Among aquatic insects, there are 13,000 described species of aquatic beetles in the world (Short 2017), of which 776 species are known from India (Chandraf et al. 2017). The Indrayani River originates in the scenic northern Western Ghats of India, specifically at Kurwande Village (18.7310°N & 73.3820°E) near Lonavala, Pune, Maharashtra. It flows eastwards from Pune, passing through the revered Hindu pilgrimage centres of Dehu and Alandi, before eventually merging with the Bhima River at Tulapur, Pune. The Indrayani River is a significant tributary of the Bhima River and it is also called as sacred river. The Valvan dam, situated on the river, serves the dual purpose of irrigation and generating hydroelectric power. Flowing along the northern border of Pune City, the river's catchment area encompasses numerous villages, housing complexes, several cities, educational institutes, and various industrial areas, including Maharashtra Industrial Development Corporation (MIDC) and over the past three decades, industrialization has been rapidly expanding in this area. The deterioration of river water quality of rivers Pawana, Mula, Mutha, and Indrayani of Pune Metropolitan area resulted from the growth of industrial activities and associated unplanned concentration of people in the suburban areas (Hui & Wescoat 2019; Bhagwat et al. 2021). There is no proper sewage collection and treatment provided for thousands of people who assemble twice a year and for the local residents. These activities are taking toll on river's health thereby affecting its faunal status as well as human health (Dahanukar et al. 2012). There are also many news reports on formation of toxic foam on the banks of the Indrayani River from factories and sewage. Therefore, the present study is focused on the aquatic beetle's diversity and to assess water quality, including water temperature, dissolved oxygen, pH, electrical conductivity, total dissolved solids and salinity from Indrayani River.

## MATERIAL AND METHODS

Collections from the Indrayani River were conducted monthly throughout the year 2022, encompassing all seasons. The beetle samples were collected from eight different sites (Image 1) of Indrayani River (Image 2) such as Valvan (site A), Kamshet (site B), Warangwadi (site C), Begadewadi (site D), Moshigaon (site E), Alandi (site F), Dhanore (site G), and Tulapur (site H). The beetles were collected using the line transects method, using a pond net with a square frame (mesh size 0.5 mm). The net was systematically swept back and forth at 100 m intervals in the water bodies. Once collected, the beetles were preserved in 70% ethanol and appropriately labelled with corresponding information about the sample sites, date, and time of collection. Collected beetles were studied and photographed under Leica EZ4 HD microscope. Identification was done using standard literature mainly by Sharp (1882), Vazirani (1968, 1984), Pederzani (1995), Toledo (2008), Nasserzadeh & Komarek (2017), Sheth et al. (2018, 2021), and Girón & Short (2021). All the identified specimens are deposited in the Zoological Survey of India, Pune with registration numbers from ENT-1/4220 to ENT-1/4267.

During the beetle collection, water samples were also collected from each sampling site. At the location of sampling, three replicates of selected physicochemical water quality parameters were recorded. The water quality parameters, such as pH, salinity, conductivity, total dissolved solids, and temperature, were measured directly on-site using a multiparameter probe Eutech PCS Tester 35. However, dissolved oxygen measurements were recorded in the laboratory, utilizing the digital bench top DO meter (Aquasol AB-DO-01). The geographic coordinates were obtained using Google Earth. Analysis of variance (ANOVA) was utilized to assess the statistical differences between the means of the water quality parameters of the Indrayani River using R-Software-version R 4.3.1 [Package R studio - (1) library (dplyr), (2) library (gplots)].

## RESULT AND DISCUSSION

A total of 94 individuals of aquatic beetles were collected from six eight sites in 36 sampling efforts during the year. There were all belonging to 31 species (Image 3–6) under 19 genera and four families from Indrayani River (Table 1). The family Dytiscidae was the most abundant with 15 species followed by Hydrophilidae with 11 species, Gyrinidae with three species, and Noteridae with two species (Figure 1). Among the family Dytiscidae, the genus *Laccophilus* was found in five out of eight sites which makes it more prevalent.

Family Hydrophilidae was found to be the second


**Image 1 . Collection sites and habitats of aquatic beetles from Indrayani River: A—Valvan | B—Kamshet | C—Warangwadi | D—Begdewadi | E—Moshigaon | F—Alandi | G—Dhanore | H—Tulapur. © P. Takawane.**

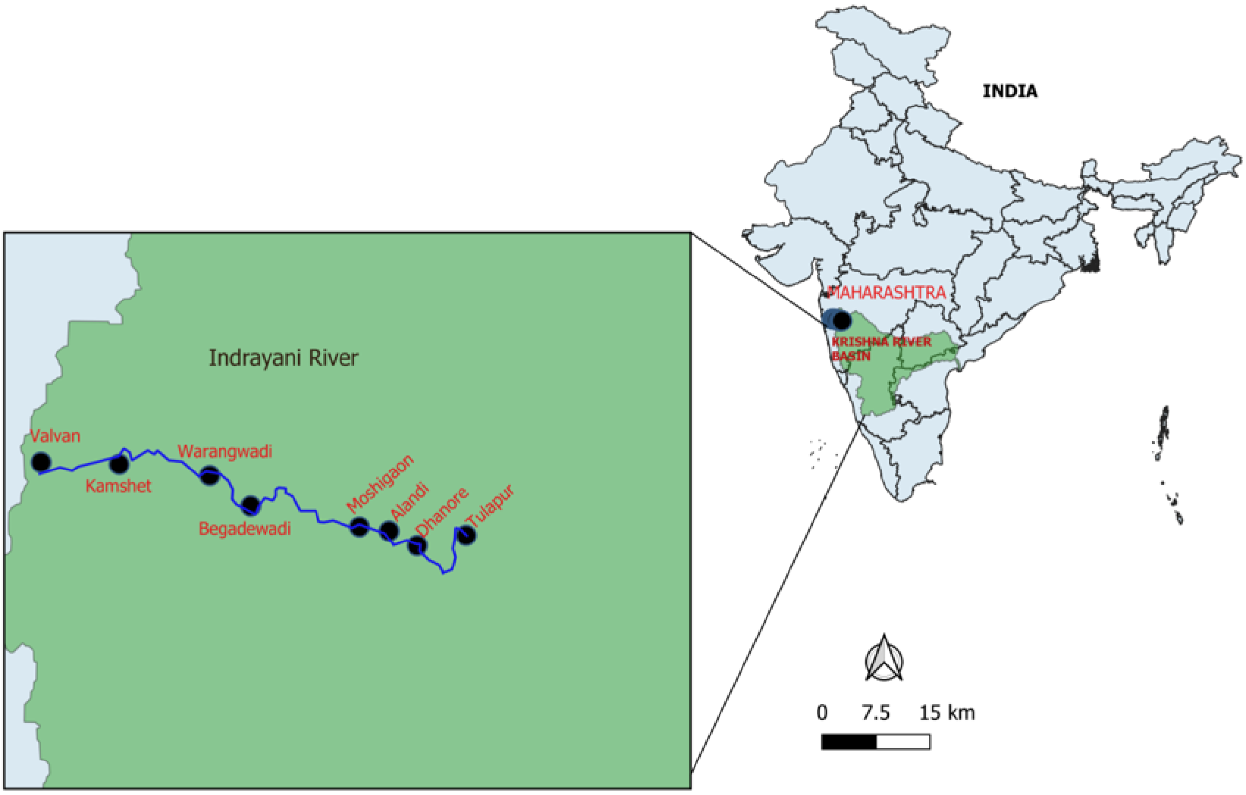


Image 2. Collection sites on the bank of Indrayani River.

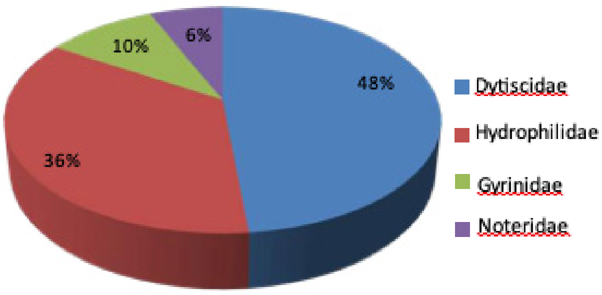


Figure 1. Graph showing species richness with respect to families in Indrayani River.

most abundant and the genus *Sternolophus* was collected more than any other hydrophilid genus from all the six localities. Two sites namely Alandi and Tulapur did not show any aquatic beetles.

The collected data of water quality for the Indrayani River from January to December 2022 is presented in Table 2. The investigation of physicochemical parameters in this study revealed that the minimum pH value was recorded at Begadewadi (pH 6.8 ± 0.14), while the maximum was observed at Alandi (pH 7.72 ± 0.46). Furthermore, the minimum water temperature was measured at Begadewadi (27.61 ± 1.90°C), and maximum temperature recorded at Alandi (28.4 ± 1.93°C). The dissolved oxygen concentration exhibited higher values at Tulapur (5.72 ± 0.30 mg/l) and the lowest values at Moshigaon (3.69 ± 0.45 mg/l). The minimum salinity recorded was 43.41 ± 16.25 ppt at Valvan, whereas the maximum salinity was observed at Dhonore, with a value of 397.41 ± 24.25 ppt. The total dissolved solids were found to be least at Warangwadi, with a measurement of 177.16 ± 32.17 ppm, and highest at Dhanore, reaching 575 ± 40.53 ppm. Furthermore, the lowest conductivity was observed at Kamshet, with a reading of 196 ± 11.15 µS/cm, while the highest conductivity value was recorded at Dhanore, measuring 784.16 ± 37.01 µS/cm. The pH, dissolved oxygen, salinity, total dissolved solids, and conductivity exhibited significant variations ($p < 0.05$) among the different sampling sites, as determined by the analysis of variance (ANOVA) (Figure 2). However, temperature did not show any significant difference. The odour of the water was unpleasant at site 5–8 and the colour of the water was slightly greenish-black to brownish-black with enormous growth of

aquatic plants like water hyacinth *Pontederia*

**Table 1. Distribution of aquatic beetles in collection sites of Indrayani River.**

| | Family | Species | Valvan | Kamshet | Warangwadi | Begadewadi | Moshigaon | Alandi | Dhanore | Tulapur |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Gyrinidae | *Dineutus (Cyclous) indicus* Aube, 1838 | + | - | - | - | - | - | - | - |
| 2 | Gyrinidae | *Patrus punctulatus* (Regimbart, 1886) | + | - | - | - | - | - | - | - |
| 3 | Gyrinidae | *Patrus limbatus* (Regimbart, 1883) | + | - | - | - | - | - | - | - |
| 4 | Dytiscidae | *Laccophilus ceylonicus* Zimmermann, 1919 | + | - | - | - | - | - | - | - |
| 5 | Dytiscidae | *Laccophilus flexuosus* Aube, 1938 | + | - | - | - | + | - | + | - |
| 6 | Dytiscidae | *Laccophilus inefficiens* Walker, 1859 | - | - | + | - | - | - | - | - |
| 7 | Dytiscidae | *Laccophilus parvulus* Aube, 1838 | - | - | - | + | - | - | - | - |
| 8 | Dytiscidae | *Hydaticus fabricii* M'Leay,1833 | + | - | - | + | - | - | - | - |
| 9 | Dytiscidae | *Hydaticus incertus* Regimbart, 1888 | + | - | - | - | - | - | - | - |
| 10 | Dytiscidae | *Hydaticus luczonicus* Aube, 1838 | - | - | - | + | - | - | - | - |
| 11 | Dytiscidae | *Copelatus neelumae* Vazirani, 1973 | - | - | - | - | + | - | - | - |
| 12 | Dytiscidae | *Copelatus schuhi* Hendrich & Balke,1998 | + | - | - | - | - | - | - | - |
| 13 | Dytiscidae | *Copelatus deccanensis* Sheth, Ghate & Hajek, 2018 | + | - | - | - | - | - | - | - |
| 14 | Dytiscidae | *Cybister sugillatus* Erichson, 1834 | - | - | - | + | - | - | - | - |
| 15 | Dytiscidae | *Hydroglyphus inconstans* (Regimbart, 1892) | - | - | - | - | + | - | - | - |
| 16 | Dytiscidae | *Hyphydrus renardi* Severin, 1890 | - | - | - | + | - | - | - | - |
| 17 | Dytiscidae | *Peschetius nilssoni* Sheth, Ghate, Dahanukar & Hajek, 2021 | - | - | + | + | - | - | - | - |
| 18 | Dytiscidae | *Peschetius toxophorus* Guignot, 1942 | + | - | - | - | - | - | - | - |
| 19 | Hydrophilidae | *Sternolophus rufipes* (Fabricius, 1792) | + | - | - | + | - | - | + | - |
| 20 | Hydrophilidae | *Regimbartia attenuata* (Fabricius, 1801) | - | - | - | + | - | - | - | - |
| 21 | Hydrophilidae | *Hydrophilus olivaceous* (Fabricius,1781) | - | - | - | + | - | - | - | - |
| 22 | Hydrophilidae | *Helochares anchoralis* Sharp, 1890 | - | - | - | + | + | - | - | - |
| 23 | Hydrophilidae | *Helochares crenatus* Regimbart, 1903 | - | - | - | + | - | - | - | - |
| 24 | Hydrophilidae | *Enochrus esuriens* Walker, 1858 | - | - | + | - | - | - | - | - |
| 25 | Hydrophilidae | *Coelostoma vitalisi* Orchymont, 1936 | - | - | - | - | + | - | - | - |
| 26 | Hydrophilidae | *Coelostoma fallaciosum* Orchymont, 1936 | + | - | - | - | - | - | - | - |
| 27 | Hydrophilidae | *Berosus (Berosus) pulchellus* M'Leay, 1825 | + | - | - | + | - | - | - | - |
| 28 | Hydrophilidae | *Amphiops mater* Sharp, 1873 | - | - | - | + | - | - | - | - |
| 29 | Hydrophilidae | *Agraphydrus obscuratus* Komerak, 2018 | + | - | + | + | - | - | - | - |
| 30 | Noteridae | *Canthydrus laetabilis* Walker, 1858 | - | - | - | + | - | - | - | - |
| 31 | Noteridae | *Canthydrus angularis* Sharp, 1882 | + | - | - | - | - | - | - | - |

+—Presence of species in the site | -—absence of species in the site .

*crassipes*, *Hydrilla* sp., *Pistia* sp. and algal blooms of Chlorophyta and Bacillariophyta on surface. Suspended sediments were also observed.

Water beetles are an important part of the biotic component of any aquatic habitat or wetlands and they are considered as indicators of ecological diversity and habitat characteristics (Foster 1987; Eyre & Foster 1989; Sánchez-Fernández et al. 2004) as they meet most of the criteria usually accepted in the selection of indicator taxa (Holt & Miller 2011). The distribution of aquatic beetles in upper basin namely Valvan, Kamshet, Warangwadi, and Begdewadi was seen more due to the quality of water and less anthropogenic disturbance as compared to the aquatic beetle's availability in lower basin namely Moshigaon, Alandi, Dhanore, and Tulapur. The river is polluted due to industrial effluents, sewage,

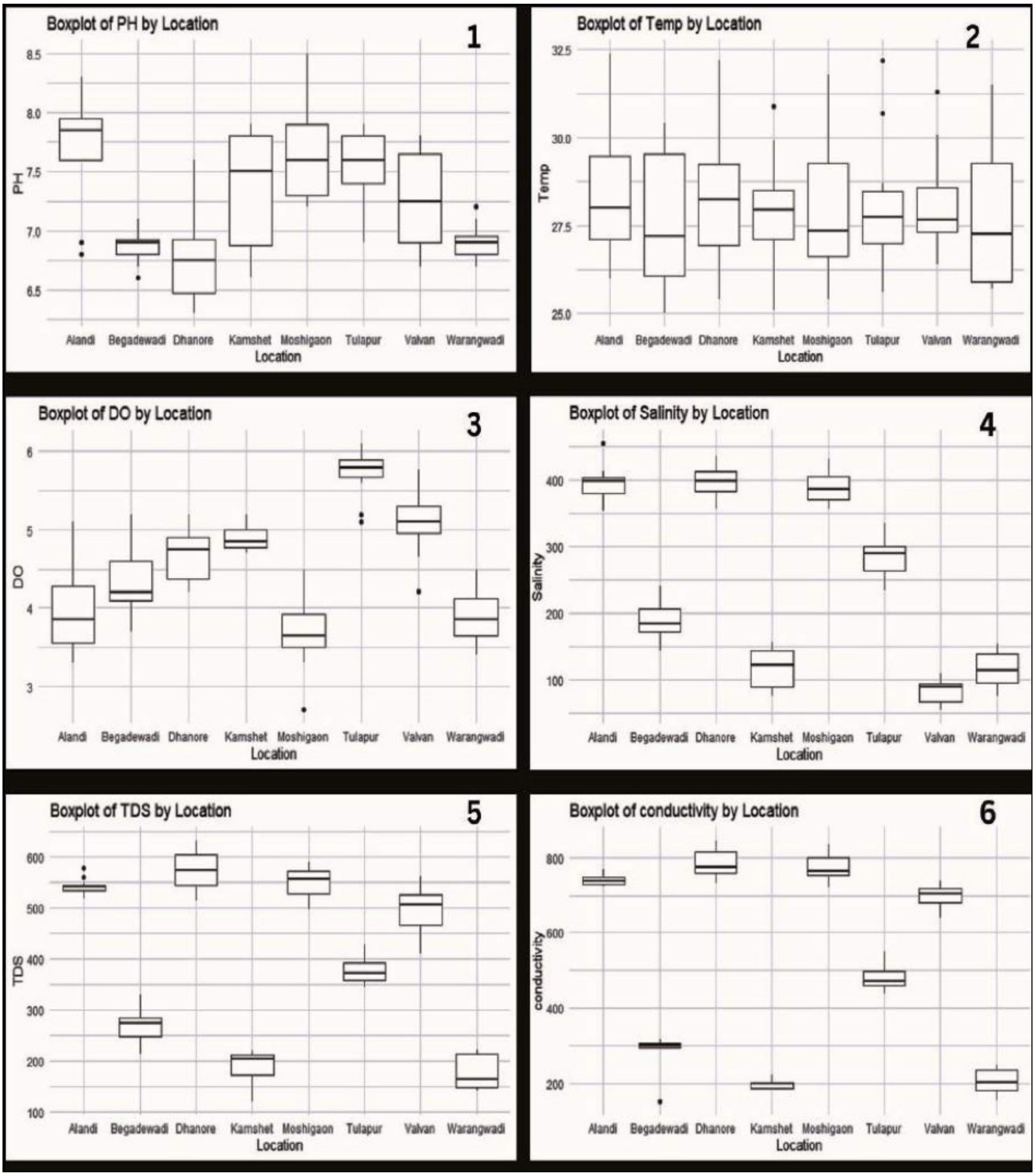


**Figure 2. Graphs of Analysis of Variance (ANOVA) of Indrayani River water: 1—pH | 2— Temperature | 3—Dissolved oxygen | 4—Salinity | 5—Total dissolved solids | 6— Conductivity.**

constructions and various recreational activities in the river basin (Dahanukar 2011). If the present activities continue, the harmful effect may lead to loss of aquatic fauna in Indrayani River. This study can be a baseline data for future research on aquatic beetles from the river as it is the first data on aquatic beetles throughout the stretch of Indrayani River.

Table 2. Physicochemical parameters of Indrayani River (January–December 2022).

| Locations | Physicochemical parameters of Indrayani River (January–December 2022) | | | | | |
|---|---|---|---|---|---|---|
| | PH | Temp (°C) | DO (mg/l) | Salinity(ppt) | TDS (ppm) | Conductivity (µS/cm) |
| | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD |
| Valvan | 7.27 ± 0.4 | 28.15 ± 1.42 | 5.08 ± 0.39 | 43.41 ± 16.25 | 500 ± 46.66 | 696 ± 30.37 |
| Kamshet | 7.33 ± 0.51 | 27.9 ± 1.71 | 4.89 ± 0.16 | 119.4 ± 28.94 | 193 ± 30.14 | 196 ± 11.15 |
| Warangwadi | 6.9 ± 0.14 | 27.83 ± 2.10 | 3.9 ± 0.36 | 114.83 ± 26.62 | 177.16 ± 32.17 | 202.25 ± 33.39 |
| Begadewadi | 6.8 ± 0.14 | 27.61 ± 1.90 | 4.39 ± 0.45 | 190.08 ± 29.30 | 267.33 ±32.20 | 289 ± 44.36 |
| Moshigaon | 7.65 ± 0.433 | 28.02 ± 2.12 | 3.69 ± 0.45 | 389.10 ± 24.28 | 547.91 ± 30.83 | 773 ± 35.36 |
| Alandi | 7.72 ± 0.46 | 28.4 ± 1.93 | 3.98 ± 0.58 | 394.25 ± 26.38 | 541 ± 16.23 | 739 ± 15.16 |
| Dhanore | 6.82 ± 0.44 | 28.27 ± 2.03 | 4.67 ± 0.33 | 397.41 ± 24.25 | 575 ± 40.53 | 784.16 ± 37.01 |
| Tulapur | 7.52 ± 0.34 | 28 ± 1.83 | 5.72 ± 0.30 | 282.75± 29.83 | 378.5 ± 27.10 | 481.41 ± 35.45 |

SD—Standard deviation | Temp—Temperature | DO—Dissolved oxygen | TDS—Total dissolved solids.

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**Image 3. Dorsal and ventral images of aquatic beetles collected from Indrayani River, Pune: 1 a & b—*Dineutus* (*Cyclous*) *indicus* Aube, 1838 | 2 a & b—*Patrus punctulatus* Regimbart, 1886 | 3 a & b—*Patrus limbatus* Regimbart, 1883 | 4 a & b—*Laccophilus ceylonicus* Zimmermann, 1919 | 5 a & b—*Laccophilus flexousus* Aube, 1938 | 6 a & b—*Laccophilus inefficiens* Walker, 1859 | 7 a & b—*Laccophilus parvulus* Aube, 1838 | 8 a & b— *Hydaticus fabricii* M'Leay, 1833.**

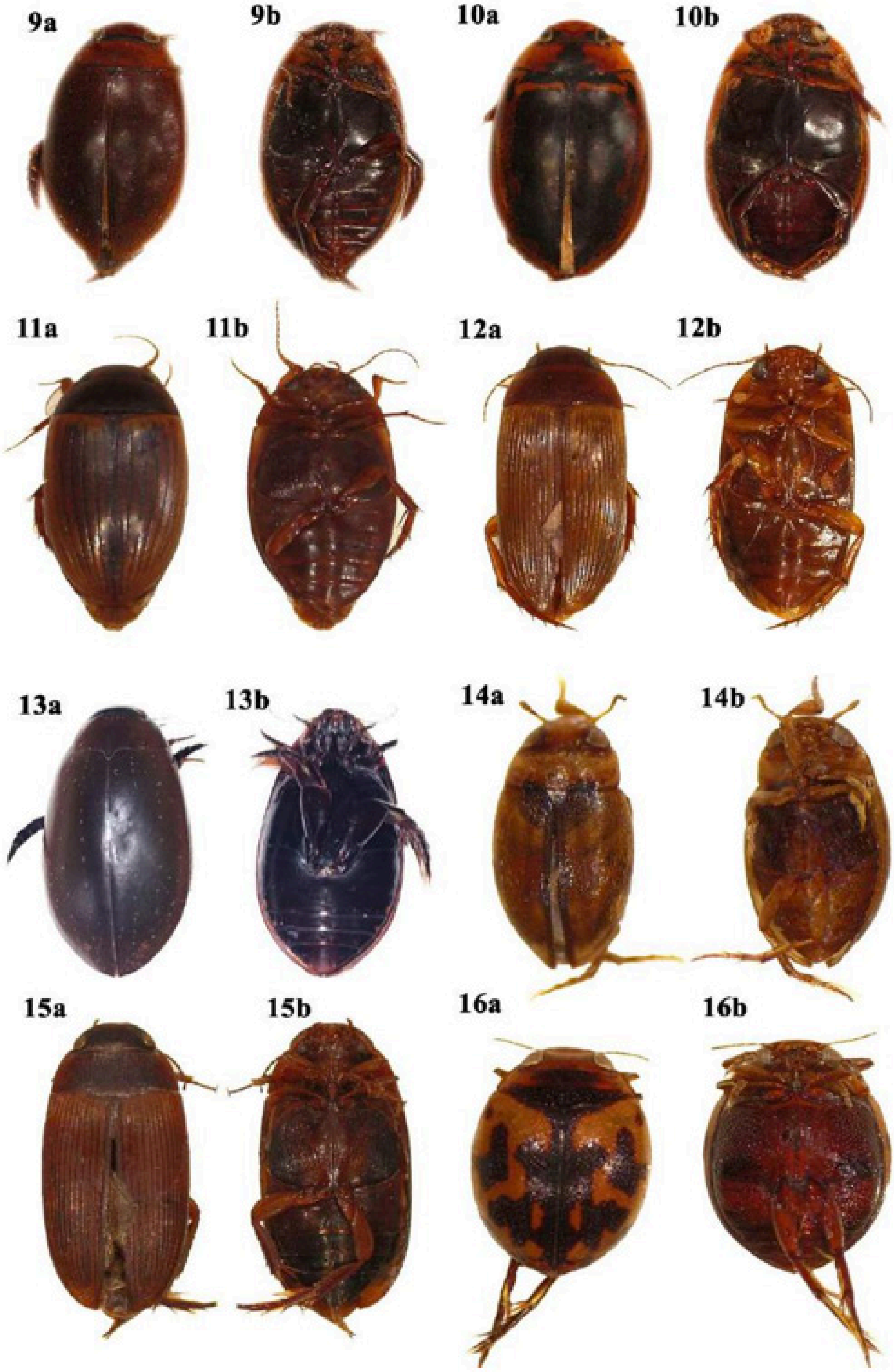


**Image 4. Dorsal and ventral images of aquatic beetles collected from Indrayani River, Pune: 9 a & b—*Hydaticus incertus* Regimbart, 1888 | 10 a & b—*Hydaticus luczonicus* Aube, 1838 | 11 a & b—*Copelatus neelumae* Vazirani, 1973 | 12 a & b—*Copelatus schuhi* Hendrich & Balke, 1998 | 13 a & b—*Cybister sugillatus* Erichson, 1834 | 14 a & b—*Hydroglyphus inconstans* Regimbart, 1892 | 15 a & b—*Copelatus deccanensis* Sheth, Ghate & Hajek, 2018 | 16 a & b— *Hyphydrus renardi* Severin, 1890.**

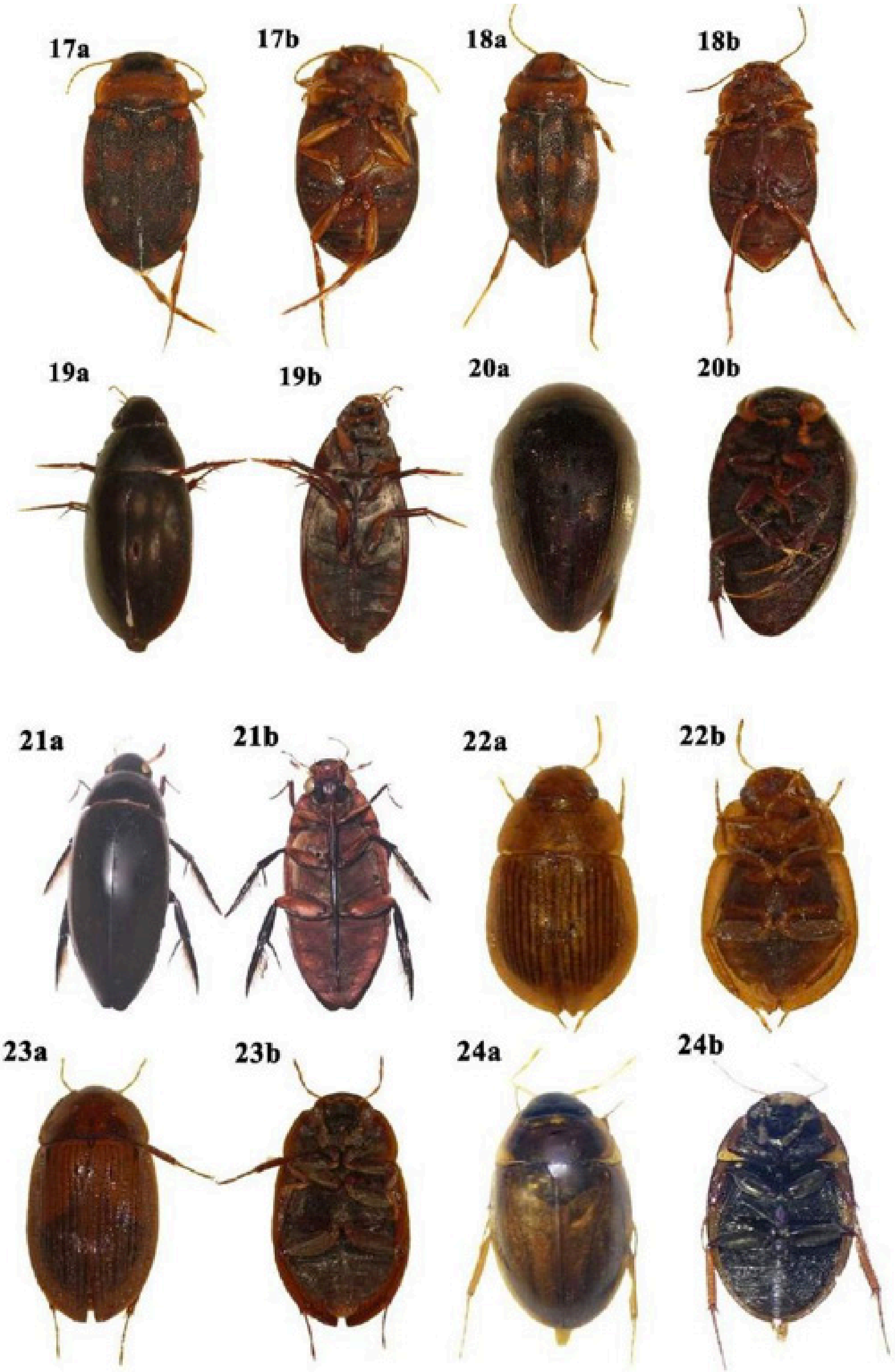


**Image 5. Dorsal and Ventral images of aquatic beetles collected from Indrayani River, Pune: 17 a & b—*Peschetius nilssoni* Sheth et al. 2021| 18 a & b—*Peschetius toxophorus* Guignot, 1942 | 19 a & b—*Sternolophus rufipes* Fabricius, 1792 | 20 a & b—*Regimbartia attenuata* Fabricius, 1801 | 21 a & b—*Hydrophilus olivaceous* Fabricius, 1781 | 22 a & b—*Helochares anchoralis* Sharp, 1890 | 23 a & b—*Helochares crenatus* Regimbart, 1903 | 24 a & b— *Enochrus esuriens* Walker, 1858.**


**Image 6. Dorsal and ventral images of aquatic beetles collected from Indrayani River, Pune. 25 a & b—*Coelostoma vitalisi* Orchymont, 1936 | 26 a & b—*Coelostoma fallaciosum* Orchymont, 1936 | 27 a & b—*Berosus (Berosus) pulchellus* M'Leay, 1825 | 28 a & b—*Amphiops mater* Sharp, 1873 | 29 a & b—*Agraphydrus obscuratus* Komerak, 2018 | 30 a & b—*Canthydrus laetabilis* Walker, 1858 | 31 a & b—*Canthydrus angularis* Sharp, 1882.**

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