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Illustrated redescription of *Haliplus* (*Liaphlus*) *arrowi* Guignot, 1936 (Coleoptera: Haliplidae) from the Western Ghats, India, and notes on the closely related *H. angustifrons* Régimbart, 1892

SAYALI D. SHETH[1], HEMANT. V. GHATE[2] & BERNHARD J. Van VONDEL[3]

[1]*Department of Biodiversity, Abasaheb Garware College, Pune–4, Maharashtra, India. E-mail: saylisheth@gmail.com*
[2]*Department of Zoology, Modern College, Shivajinagar, Pune–5, Maharashtra, India. E-mail: hemantghate@gmail.com*
[3]*Natuurhistorisch Museum Rotterdam, c/o Roestuin 78, 3343 CV Hendrik-Ido-Ambacht, The Netherlands. E-mail: haliplus@kabelfoon.nl*
Corresponding author: Sayali D. Sheth saylisheth@gmail.com

Abstract

In an ongoing survey of aquatic beetles, the crawling water beetles *Haliplus (Liaphlus) arrowi* Guignot, 1936 and *Haliplus (Liaphlus) angustifrons* Régimbart, 1892 were found only from four (three localities for *H. arrowi* and one locality for *H. angustifrons*) out of 85 localities sampled in and around the Western Ghats of Maharashtra. Digital images and scanning electron micrographs of diagnostic characters are provided for the first time for both the species. Intraspecific and interspecific variation in the elytral maculation of *H. arrowi* and *H. angustifrons* is illustrated.

Key words: Crawling water beetles, maculation, SEM, metasternal pits, Oriental

Introduction

The family Haliplidae (crawling water beetles) is one of the predominant aquatic beetle families (Jäch & Balke 2008), distributed globally except the Antarctica and New Zealand (Prokin & Ponomarenko 2013). Currently 240 species are known from the family which is classified into five genera (Vondel 2013). *Haliplus* is the most species rich genus from the Haliplidae (Prokin & Ponomarenko 2013). The genus is further subdivided into the subgenera: *Haliplus* s. str., *Neohaliplus* Netolitzky, 1911, *Haliplidius* Guignot, 1928, *Liaphlus* Guignot, 1928, *Paraliaphlus* Guignot, 1930 and *Phalilus* Guignot, 1935 (Vondel 2005). According to Vazirani (1984) all known species of *Haliplus* in India belong to the subgenus *Liaphlus*. Vondel (2005) recorded a total of 10 species in India. Previously, only *Haliplus* (*Liaphlus*) *kapuri* Vazirani, 1975 and *H. angustifrons* Régimbart, 1892 were the known species from the Maharashtra State (Vazirani 1984, Vondel 1993). However, recently *H. arrowi* was nominally reported for the first time from the State of Maharashtra (Kulkarni *et al*. 2015). The study (Kulkarni *et al*. 2015) represented the faunistics of a small temporary pond in Savitribai Phule Pune University campus, Pune in which *H. arrowi* was recorded from Maharashtra, for the first time. The distribution range of *H. arrowi* was thus extended westward from the type locality (Kolkata) of the species (type locality highlighted in the map, Figure 1). Here, recent and previous records of both the species are indicated in the map (Figure 1).

We are presenting here an illustrated redescription of *H. arrowi,* aided with digital images and scanning electron micrographs (SEM) of diagnostic characters of *H. arrowi* and *H. angustifrons* for the first time. Variation in the elytral maculation is also illustrated. Therefore, the present study adds important details to the original descriptions by Guignot (1936) and Régimbart (1892), and to the redescriptions by Vondel (1993). On the basis of the shape of the male genitalia, the distance between the eyes and overall morphology, our *Haliplus* specimens collected during the survey belong to *H. arrowi* and *H. angustifrons*.

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Materials and methods

H. arrowi and *H. angustifrons* specimens were collected from four (three and one locality, respectively) out of 85 localities surveyed in and around Western Ghats of Maharashtra (sampling period: 2013 to 2015). Specimens were collected using handheld net (mesh 1mm, 25x25cm dimensions) and then preserved in absolute alcohol. Collections were done by Sayali D. Sheth from Localities: (i) Dighi pond (18°38'19.06"N, 73°52'40.56"E, 600m ASL), Pune (Figure 3A); (ii) Savitribai Phule Pune University (18°33'16.92"N, 73°49'26.86"E, 560m ASL), Pune (Figure 3B); (iii) Bhugaon (Manas) Lake (18°29'44.16"N, 73°44'9.73"E, 637m ASL), Pune, (iv) Hatti lake (17°40'54.48"N, 73°58'18.84"E, 760m ASL), Satara. The specimens were photographed and prepared for Scanning electron micrography (SEM) as described earlier by Sheth & Ghate (2014). The diagnostic parts were photographed under Olympus CX41 at different focal planes. Images were stacked using COMBINE ZP (www.hadleyweb.pwp.blueyonder.co.uk/). Line drawings were prepared using Inkscape (vector graphics free software version 0.48.4.0 https://inkscape.org/en/download/). Specimens were measured in a horizontal position under Leica S8 APO. Measurements taken are: total length, maximum width, pronotal length, pronotal width, distance between eyes and eye width (Table 1). The geographical coordinates were obtained using Google Earth©. Map was prepared in DIVA-GIS (v 7.5c) (www.diva-gis.org) and edited in CorelDraw X5.

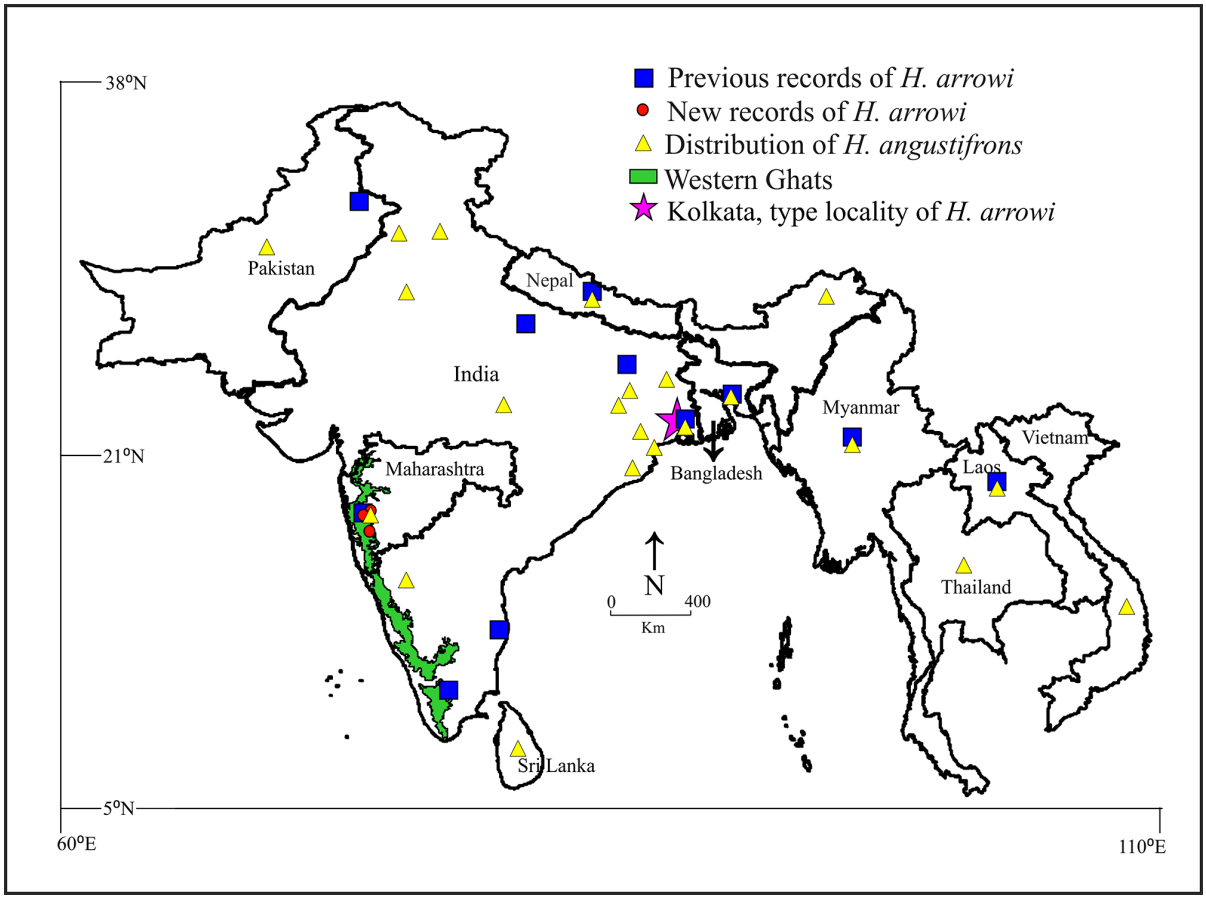

FIGURE 1. Distribution map for *H. arrowi* and *H. angustifrons* with previous and latest localities from the Oriental region. Red dots and blue squares—recent and previous records of *H. arrowi* from the Oriental region, respectively. Yellow triangles—known records of *H. angustifrons* from the Oriental region.

Results

Illustrated redescription: *Haliplus* (*Liaphlus*) *arrowi* Guignot, 1936

Known distribution from the Oriental region: India (West Bengal- Kolkata, Bihar- Ajay River, Uttar Pradesh, Tamil Nadu- Chennai & Palni hills, Maharashtra- Savitribai Phule Pune University, Pune 18°33'16.92"N, 73°49'26.86"E, 560m ASL), Nepal, Myanmar (previously Burma), Laos, Pakistan and Bangladesh (Vazirani 1984; Vondel 1993, 2009; Kulkarni *et al* 2015).

New records: Maharashtra- Dighi pond (18°38'19.06"N, 73°52'40.56"E, 600m ASL), Pune; Hatti lake (17°40'54.48"N, 73°58'18.84"E, 760m ASL), Satara (Figure 1).

Material Studied: SDS & HVG studied 22 males and 15 females from Pune and Satara. BJVV examined the type specimen and additional specimens from India (Vondel 1993).

Habitus: form oval, head narrower than pronotum, body widest near base of elytra, more attenuated posteriorly, both dorsal and ventral surfaces bear numerous setiferous punctures (magnified view in Figure 2G), all dorsal punctures with black pigmentation at base.

Head: pale brown without any black pattern; widest across eyes, eyes cover most of head's area; antennae brownish yellow, placed anterior to eyes, 11 segmented, 1st , 2nd segments broad, 3–6 segments short, narrow while 7–11 segments long, broad, 11th segment largest (Figure 2A); clypeus roughly trapezoid not covering labrum completely; labrum setose anteriorly, medially with small depression; maxillary palps brownish yellow, four segmented, last segment terminating in sharp point, shorter than penultimate; head surface covered with setiferous punctures more dense anteriorly.

Pronotum: pale cream on disc while brownish yellow along margins; arc shaped, widest at base, narrow towards apex, anterior angles acute, posterior angles more or less rounded, postero-medially sharp protrusion covering scutellar region; punctation- punctures present along margins, rather scarce on disc (sometimes present in longitudinal lines on disc), anterior punctures small, posterior punctures large with black pigmentation at their base, punctures continue along lateral margin (Figure 3C & 2B).

Elytra: overall brownish yellow with small black patches on elytra as extending from suture towards lateral margins; moderately convex, widest sub-basally, tapering towards apex after middle; 17–18 alternate rows of primary and secondary setiferous punctures (Figure 2C), 25 punctures in first primary puncture row; elytral epipleura widest in basal region, with a notch before middle to fit lateral extensions of enlarged metacoxal plates then gradually tapering towards apex, epipleura with two parallel lines of setiferous punctures in basal half (Figure 2D), a single line of punctures continues in apical half; polygonal microstructure absent.

Prosternum: prosternum pale anteriorly but dark brown posteriorly (Figure 3C); broad, raised and continued in same plane of metasternum, heavily punctate with setiferous punctures, posteriorly with shallow but distinct pit (Figure 2E).

Metaventrite: raised antero-medially with large depression, setiferous punctures present (Figure 2E); metepisternum smooth, completely separating metasternum from elytral epipleura; anterolateral corners have two shallow pits which appear connected (Figure 2D); antecoxal sclerite punctate (Figure 2F) (anteriorly large, posteriorly small setiferous punctures).

Abdomen: three segments visible, each segment posteriorly lined by setiferous punctures, enlarged metacoxal plates cover basal segments which bear depression to fit metacoxal plate (Figure 3E).

Fore and mid legs: coxae globular, completely separated, apically notched, 1/3rd area with patch of adpressed setae anteriorly, medially with larger setiferous punctures; trochanter short, attached posteriorly to coxa, adpressed setae almost obsolete; femur basally as well as apically narrowed, medially enlarged, surface covered with dense, coarse micropunctures; tibial inner margin with long hairs, apically two equal spurs present (Figure 2D&E); tarsi 5 segmented, 5th segment longest, basal three tarsal segments in males bear a bunch of adhesive setae coming out of single point at their apical end (Figure 2H), tarsal claws of equal length. Hind legs: coxal plates enlarged covering trochanter and most of the femoral region (Figure 3D), bear setiferous punctures on entire surface, punctures small in centre while become large towards lateral side and anterior side (Figure 2F); femur broadest at base; tibia slender with unequal metatibial spurs (Figure 3D); tarsi 5 segmented bear setae, 1st segment longest, claws equal. All tibia and tarsi with long hairs along their inner margins.

Male genitalia: median lobe slightly curved, apex rounded, more spatulate (Figure 3F); parameres unequal (Figure 3G&H), right paramere with toe like process (Figure 3G).

Variation: *H. arrowi* specimens do not vary much in their overall size (Table 1). However, there is a variation in the elytral maculation of specimens from all three localities. The species shows variation in maculation as individuals from Hatti Lake (Figure 4A) and UoP pond (Figure 4 C to E) show broader and denser maculation. On the contrary, specimens from Dighi pond show comparatively thinner and rarer maculation (Figure 4 F to I). However, there is no fixed pattern of the maculation for every group, as it also varies in the specimens from the same locality.

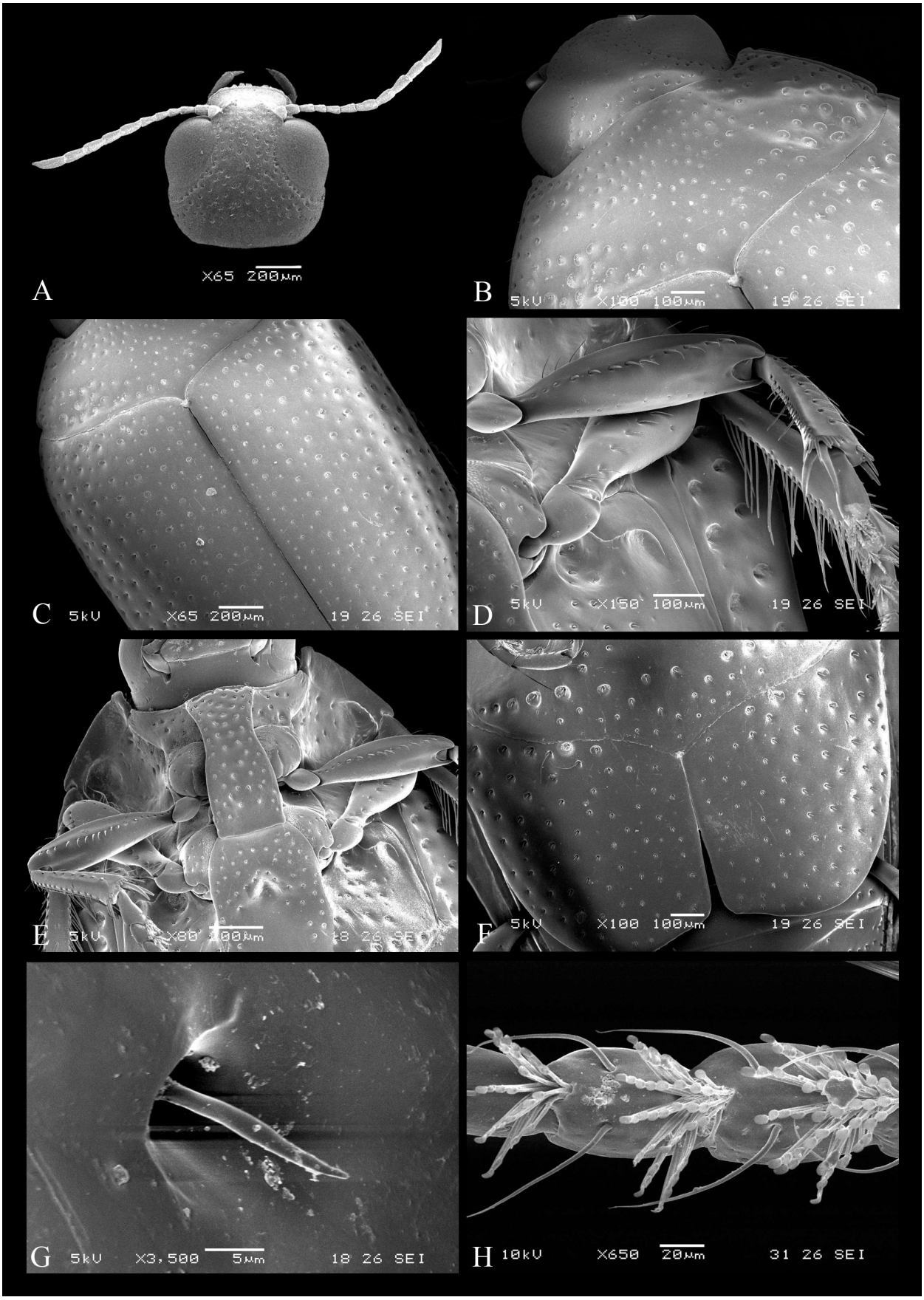

FIGURE 2. *H. arrowi* (all SEM images), A—Head; B—Pronotum; C—Elytra; D—Elytral epipleura & anterolateral metasternal region; E—pro and metasternal region; F—metacoxal plates; G–magnified view of a setiferous puncture; H—Adhesive structures on male protarsomeres.

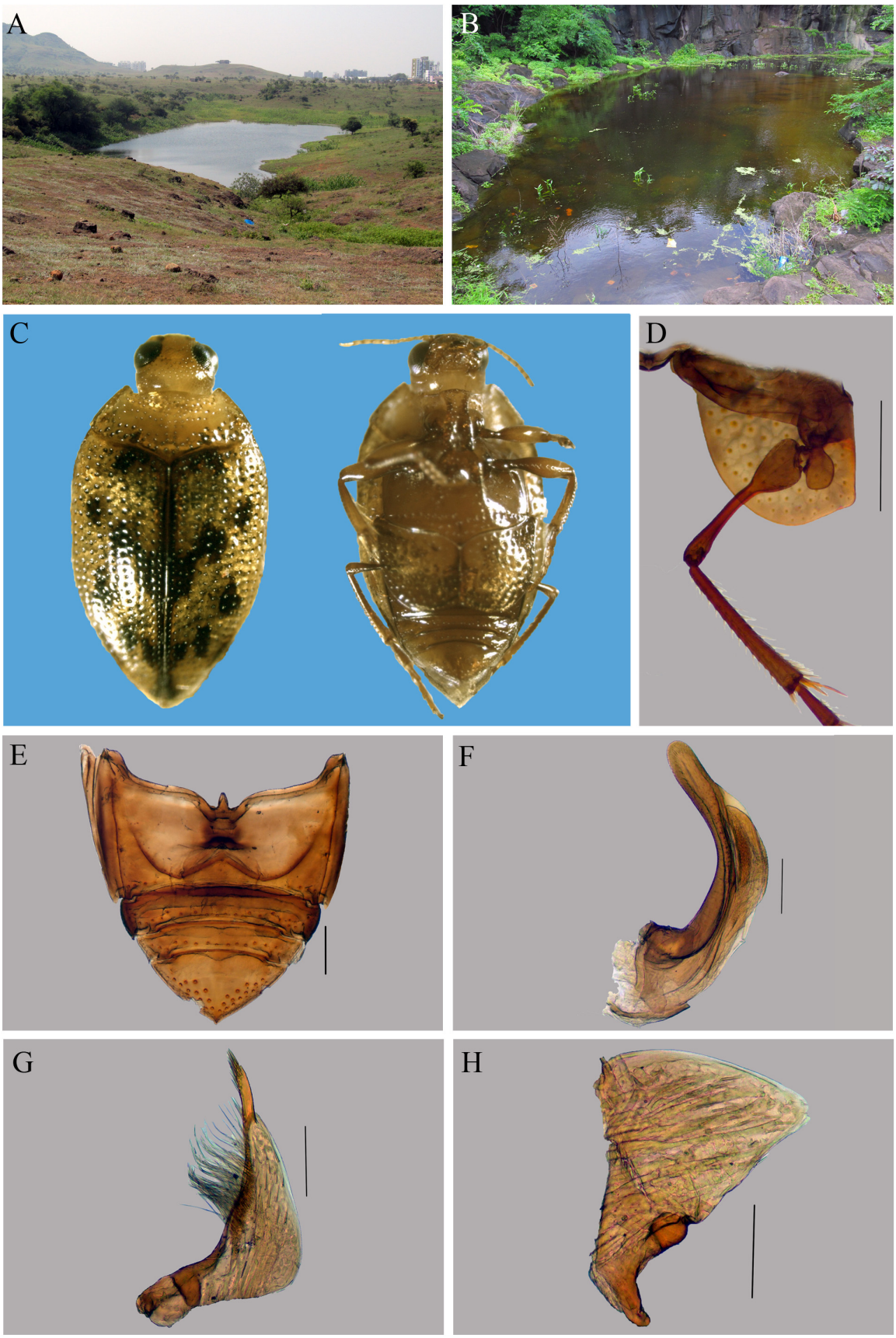

FIGURE 3. A—Dighi pond, Pune; B—Savitribai Phule Pune University pond, Pune; *H. arrowi*, C—dorsal &ventral view (length 3 mm); D—Hind leg (scale 500µm); E—Abdomen ventral (scale 100 µm); F—median lobe (scale 100µm); G&H—right & left parameres, respectively (scale 100µm).

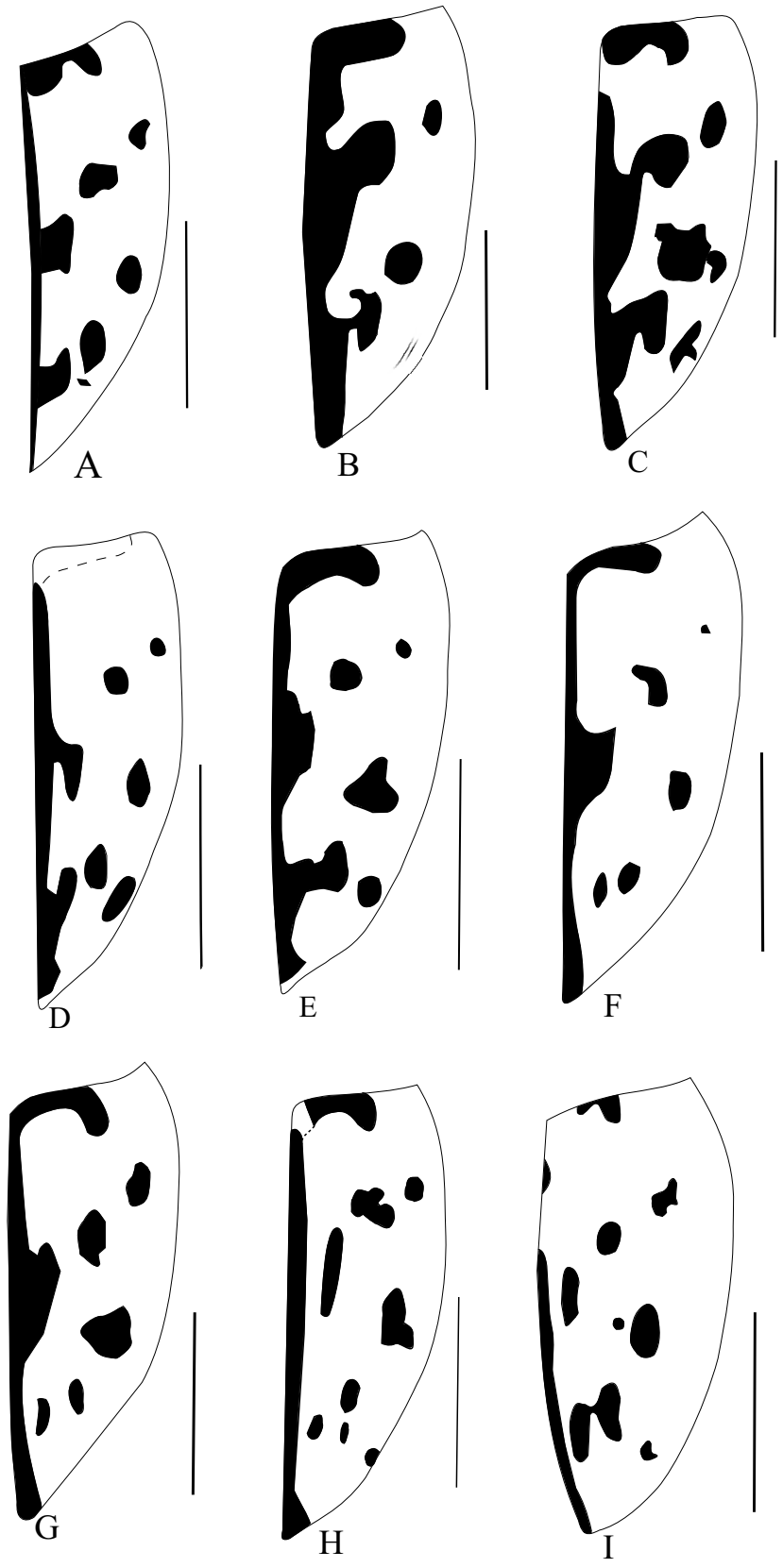

FIGURE 4. Variation in the elytral maculation (scale 1mm): *H. arrowi* (A, C–I); *H. angustifrons* (B).

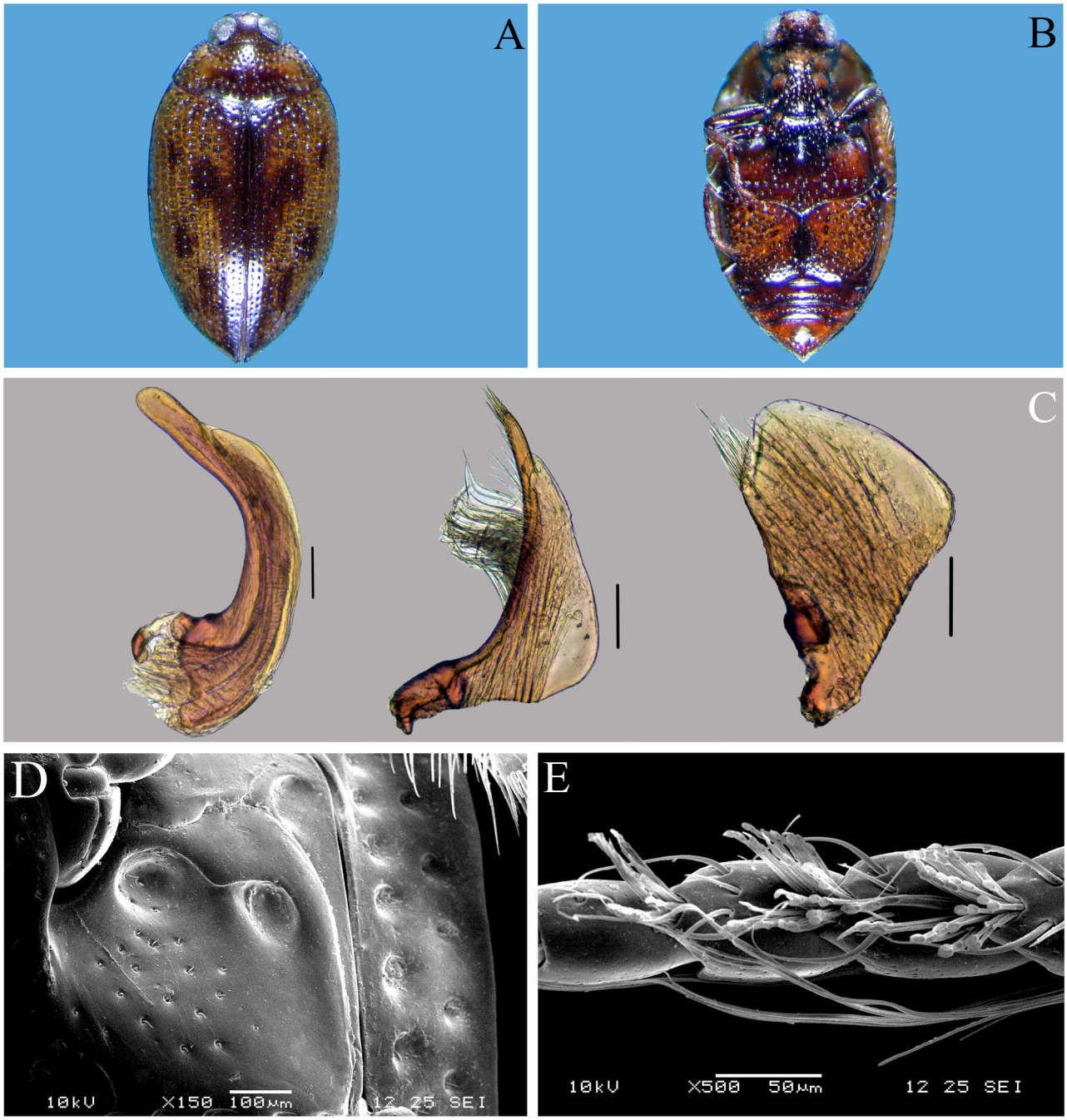

FIGURE 5. *H. angustifrons*, A & B—Dorsal & ventral habitus; C—male genitalia (scale 100µm); D—SEM of anterolateral metasternal pits; E—SEM of male protarsi.

***Haliplus (Liaphlus) angustifrons* Régimbart, 1892**

Known distribution from the Oriental region: India (Punjab; Himachal Pradesh- Simla hills; Jharkhand-Ranchi district (previously in Bihar now in Jharkhand), Hazaribagh district (previously in Bihar now in Jharkhand), Santhal paraganas district (previously in Bihar now in Jharkhand); Kolkata-West Bengal; Odisha (previously Orissa)- Cuttak district, Balasore district, Mayurbanj district; Madhya Pradesh- Jabalpur; Rajasthan- Pilani; Arunachal Pradesh; Maharashtra; Karnataka), Myanmar, Nepal, Pakistan, Laos, Vietnam, Thailand and Bangladesh (Vazirani 1984; Vondel 1993, 2015) (Figure1).

Material studied. SDS & HVG studied single specimen (male) from Bhugaon Lake, Pune; BJVV examined the type specimen and additional specimens from India (Vondel 1993).

Distinguishing characters from *H. arrowi*: Head overall brown, dorsally eyes closer than that in *H. arrowi*-distance between eyes 0.7 times width of one eye; pronotum darker on disc than on sides (Figure 5A); elytral maculation extensive against moderately dense to rare maculation in *H. arrowi* (Figure 4B), twenty rows of primary and secondary punctures present per elytron, 30 punctures in first primary-puncture row; ventrally brown, prosternum posteriorly with deeper pit than that in *H. arrowi* (Figure 5B), metaventrite with two deeper and less connected pits anterolaterally (Figure 5D); protarsi narrower and slender (Figure 5E); median lobe of male genitalia narrower and less spatulate in apical region (Figure 5C).

TABLE 1. Measurements of *Haliplus* specimens: TL—total length measured from head to the elytral tip; MW–maximum width of specimen measured across elytra; PL—medial length of pronotum; PW—maximum width of pronotum measured at its base; DE—minimum distance between eyes, and EW—maximum width of one eye. All measurements are in mm.

Characters	*H. arrowi* (n=37) Mean ± standard deviation	*H. angustifrons* (n=1)
TL	3.10 ± 0.18	3.57
MW	1.71 ± 0.10	2
PL	0.65 ± 0.05	0.7
PW	1.37 ± 0.08	1.58
DE	0.26 ± 0.02	0.216
EW	0.23 ± 0.03	0.3

Key to the *Haliplus* species

1. Pronotal base protruding (Figure 5A), 1st row of secondary punctures on elytra dense and sometimes irregular at base, distance between eyes is 0.7 times width of one eye, prosternal process anteriorly as wide as posteriorly, anterolateral metasternal pits deeper and more separated (Figure 5D) . . . . . *H. angustifrons*

- Pronotal base not protruding (Figure 3C), 1st row of secondary punctures on elytra sparse at base, between eyes distance is 1.1 times width of one eye, prosternal process wider posteriorly than anteriorly, anterolateral metasternal pits shallow and less separated (Figure 2D) . . . . . *H. arrowi*

Discussion

For the first time, we provide digital images and scanning electron micrographs of the species *H. arrowi* and *H. angustifrons*. Khalaf (1980) studied the elytron microstructure of different groups of beetles based on replica technique of electron microscopy. Balfour-Browne (1940) suggested polygonal pattern might be the ancestral pattern of beetles. Hinton (1970) suggested that polygonal microstructure of the insect cuticle is the common pattern in insects. According to Khalaf (1980) the basic polygonal pattern on the elytron is lost in the Haliplidae family and only micropunctures remains, together forming spots as a modification. According to Balfour-Browne (1940) such spots are the evidence that the family did evolve from an ancestor which had the polygonal microstructure pattern. We also verified elytral microstructure of *H. arrowi* and our observations match with those by Khalaf (1980).

Vondel (1993) revised the subgenus *Liaphlus* from the Oriental region and provided a key to the Oriental species. 'Presence of setiferous striole on dorsal face of hind tibia, absence of basal plicae on pronotum and male parameres with solid digitus' are defining characteristics of the subgenus (Vondel 1991). Based on these characteristics our specimens belong to the subgenus *Liaphlus*. Keys and descriptions by Vondel (1993) and Vazirani (1984) further confirm that our specimens belong to *H. arrowi* and *H. angustifrons*.

Vazirani (1984) described a new species, *H. kapuri* from Satara district of Maharashtra, based on single male specimen. According to Vondel (1993) 'there is some doubt about the three species described by Vazirani (*kapuri*, *manipurensis* and *pruthii*), as some parts of the descriptions are not clear, especially shape of prosternal process'. Haliplus species collected during the survey from Satara belong to *H. arrowi* based on Vondel (1993).

H. arrowi and *H. angustifrons* were studied for their additional distinguishing characters. Scanning electron micrographs of anterolateral metasternal pits and male protarsi revealed that the species apparently vary more in anterolateral metasternal pits, though additional specimens must be studied. The two species differ in many characters, although the differences are minor.

H. arrowi shows variation in its elytral maculation. The maculation varies along suture as well as on the disc (from blotches to just a spot, sometimes obsolete). The specimens of *H. arrowi* show a large amount of variation within a small geographical region. The sites from where the specimens were collected are located within the range of 115 km. However, large numbers of samples over a wider geographical area should be studied in future to establish such interesting patterns within species.

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