

# New species and records of Palaearctic Campopleginae, Cryptinae, Hybrizontinae, and Tersilochinae (Hymenoptera: Ichneumonidae)

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**Abstract.** The following taxonomical and faunistical results are presented in this paper: regarding Campopleginae, *Lathrostizus atrox* sp. nov. and *Phobocampe kaszabi* sp. nov. are described from Mongolia, and the first records of *Phobocampe brumatae* Horstmann, 2009, *Phobocampe pulchella* (Thomson, 1887) and *Phobocampe quercus* Horstmann, 2008 from Hungary, and *Clypeoplex cerophagus* (Gravenhorst, 1829) from Bulgaria are reported; regarding Cryptinae, *Thaumatogelis lichtensteini* (Pfankuch, 1913) is first reported from Moldova; regarding Hybrizontinae, the first records of *Ghilaromma ussuriensis* Tobias, 1988 from North Korea, *Hybrizon buccatus* (Brebisson, 1825) from Serbia, Kosovo, Romania and North Korea, *Hybrizon ghilarovi* Tobias, 1988 from Germany, and *Hybrizon pilialatus* Tobias, 1988 from Romania are reported; regarding Tersilochinae, the first Hungarian records of *Probles (Euporizon) truncorum* (Holmgren, 1860) and *Tersilochus (Tersilochus) obliquus* (Thomson, 1889) are given.

**Keywords.** *Clypeoplex*, *Ghilaromma*, *Hybrizon*, *Lathrostizus atrox* sp. nov., *Phobocampe kaszabi* sp. nov., *Probles*, *Tersilochus*, *Thaumatogelis*

## INTRODUCTION

The continuing identification process of the Ichneumonidae material in the Hungarian Natural History Museum (HNHM, Budapest) already resulted in several taxonomical and faunistical discoveries regarding the Palaearctic region in the recent years (see e.g. Vas 2013, Vas *et al.* 2015, Vas 2015, 2016a, b, c, d, e, Vas & Kutasi 2016, Vas & Schwarz 2018, Vas 2018, 2019a, b, c, d, e). The most recent results are presented in this paper as follows. Two new species of Campopleginae, *Lathrostizus atrox* sp. nov. and *Phobocampe kaszabi* sp. nov. are described from Mongolia, and 11 species of subfamilies Campopleginae, Cryptinae, Hybrizontinae and Tersilochinae are first reported from eight countries of the Palaearctic region.

## MATERIAL AND METHODS

Taxonomy and nomenclature follow Yu & Horstmann (1997), and Yu *et al.* (2012); hence, complete nomenclatural history and list of syno-

nym taxa are not repeated here. The applied morphological terminology is primarily based on Gauld (1991) and Gauld *et al.* (1997); however, in some cases, especially about of wing veins, the corresponding terminology of Townes (1969) is also given. Identifications were based on Uchida (1954), Horstmann (1971a, b, 1978, 1981), Kasparyan (1981), Gupta (1983), Kusigemati (1988, 1993), Xu & Sheng (1994), He *et al.* (1996), Achterberg (1999), Jonathan (1999), Schwarz (2001), Horstmann (2004), Šedivý (2004), Khalaim & Kasparyan (2007), Horstmann (2007, 2008, 2009), Khalaim & Yurtcan (2011), Choi *et al.* (2012), Konishi *et al.* (2012), Achterberg *et al.* (2013), Vas & Schwarz (2018), Liu *et al.* (2019), and on checking the relevant type materials. Distributional records of species were primarily checked and traced through the database of Yu *et al.* (2012). The specimens were identified and examined by the author using a Nikon SMZ645 stereoscopic microscope, and are deposited in the Hymenoptera Collection of HNHM. Photos were taken with Nikon D5200 and Nikon AF Micro Nikkor 60mm lens and MitutoyoM Plan Apo 5X

microscope lens. Exposures were stacked in ZereStacker 1.04, post image work was done with ImageJ 1.52c and Photoshop CS5.

## RESULTS

### Taxonomy

#### Campopleginae Förster, 1869

##### *Lathrostizus* Förster, 1869

*Type species.* *Lathrostiza stenocera* Thomson, 1887; designation by Viereck (1914).

##### *Lathrostizus atrox* sp. nov.

(Figures 1–2)

*Material examined.* Holotype: female, Mongolia, Central aimak, Ulan-Baator, Nucht im Bogdoul, 1880–2000m, 9.VI.1966, leg. Z. Kaszab (Nr. 508); specimen card-mounted; Id. No. HNHM-HYM 153173. – The holotype is deposited in the Hymenoptera Collection of HNHM (Budapest, Hungary).

*Diagnosis.* The new species can be distinguished from all known *Lathrostizus* species by the following characters in combination: posterior transverse carina of mesosternum strong, distinctly elevated, not forming backward projecting lobe, submedially slightly convex, medially shallowly indented; area superomedia little longer than wide, its lateral sides arched, divergent above and convergent below the level of costulae; ovipositor sheath 1.25× as long as first tergite, ovipositor distinctly upcurved in apical third, slightly upcurved in basal two-third; all legs with coxae, trochanters, trochantelli black, femora almost entirely black, apically narrowly ferruginous, tibiae entirely ferruginous, tarsi ferruginous, apically brownish. The new species is somewhat similar to the Western Palaearctic species *Lathrostizus alpinus* Horstmann, 1971, which can easily be distinguished from the new species by its basally ivory, subbasally and apically blackish hind tibia.

*Description.* Female (Figs. 1–2). Body length ca 5.5 mm, fore wing length ca 4 mm.

*Head.* Antenna with 25 flagellomeres; first flagellomere ca 2.5× as long as its apical width; preapical flagellomeres slightly longer than wide. Head transverse, granulate, and with relatively short, dense greyish hairs. Ocelli small, ocellar-ocellar distance 1.4× as long as ocellus diameter, posterior ocellar distance ca 2.5× as long as ocellus diameter. Inner eye orbits slightly indented, parallel. Gena (temple) long, swollen, in dorsal view about as long as eye width, subparallel then slightly narrowed behind eye; gena in lateral view wider than eye width along ventral half of eye length, ventrally weakly narrowed and concave. Occipital carina complete, ventrally weakened, reaching hypostomal carina distinctly before mandibular base; hypostomal carina slightly elevated. Malar space ca 0.75× as long as basal width of mandible. Face and clypeus almost flat in profile, weakly separated; maximum face width about as wide as frons below middle ocellus. Clypeus wide, granulate with few indistinct, superficial punctures, its apical margin truncate, sharp. Mandible relatively long, lower margin of mandible with wide carina from teeth toward base, mandibular teeth about equal.

*Mesosoma.* Mesosoma granulate to coarsely granulate with weak, superficial, indistinct punctures, and with short, greyish hairs, hairs denser on dorsal parts than on lateral parts, and longer on propodeum. Pronotum with relatively strong, irregular wrinkles on lower two-third; epomia distinct. Mesoscutum convex in profile, about as long as wide; notaulus not developed. Scuto-scutellar groove deep and wide, almost smooth within. Scutellum strongly convex in profile, without lateral carina. Mesopleuron coarsely granulate with irregular wrinkles anterodorsal to speculum and along anterior margin; speculum mostly granulate, ventrally a small spot very finely granulate to almost smooth; mesopleural suture with short transverse costae. Pleural and ventral part of epicnemial carina complete, strong; transverse part (*i.e.* part at the level of sternaulus running through the epicnemium to the ventral edge of pronotum) absent; pleural part obliquely



Figures 1–2. Holotype of *Lathrostizus atrox* sp. nov., female. 1 = lateral habitus; 2 = posterior transverse carina of mesosternum (posterior half of mesosternum in ventral view is depicted, head upward).

bent to anterior margin of mesopleuron reaching it below its middle height, ventral part slightly elevated. Sternaulus indistinct. Posterior transverse carina of mesosternum complete, strong, distinctly elevated, not forming backward projecting lobe, submedially slightly convex, medially shallowly indented. Metanotum finely granulate, about  $0.5\times$  as long as scutellum. Metapleuron granulate; juxtacoxal carina absent; submetapleural carina complete. Pleural carina of propodeum complete; propodeal spiracle small, subcircular, separated from pleural carina by about  $2\times$  its greatest diameter, spiracle connected to pleural carina by a weak ridge. Propodeum coarsely granulate to rugose, with distinct transverse wrinkles; propodeal carinae relatively weak except basal parts of lateromedian longitudinal carinae. Costula (section of anterior transverse carina between lateromedian and lateral longitudinal carinae) present but weak, especially distally, and connected to lateral margin of area superomedia slightly behind its middle. Area basalis very small and short, trapezoidal, about half as long as its basal width. Area superomedia about  $1.2\times$  as long as its greatest width, its lateral sides arched, rather divergent above the level of costulae, little convergent below the level of costulae; area superomedia apically opened, confluent with area petiolaris, both areas densely covered with transverse wrinkles. Fore wing with long-stalked, rather small areolet, second recurrent vein ( $2m-cu$ ) dis-

tinctly distal to its middle,  $3rs-m$  pigmented; distal abscissa of  $Rs$  straight, its distal fourth slightly bent toward anterior wing margin; distal half of distal abscissa of  $M$  weakly pigmented; nervulus ( $cu-a$ ) postfurcal by about its width, slightly inclivous; postnervulus (abscissa of  $Cu1$  between  $1m-cu$  and  $Cu1a + Cu1b$ ) intercepted little below its middle by  $Cu1a$ ; lower external angle of second discal cell about right-angled. Hind wing with nervellus ( $cu-a +$  abscissa of  $Cu1$  between  $M$  and  $cu-a$ ) about vertical, not intercepted; discoidella (distal abscissa of  $Cu1$ ) not connected to nervellus, spectral. Coxae finely granulate. Hind femur relatively stout, ca  $4\times$  as long as high. Inner spur of hind tibia distinctly longer than outer spur, inner spur ca  $0.6\times$  as long as hind basitarsus. Hind basitarsus without a midventral row of closely spaced, short hairs. Tarsal claws small, slightly shorter than arolium, with few weak basal pecten.

*Metasoma.* Metasoma moderately compressed, granulate to coriaceous, with weak, hardly discernible punctures on apical tergites and epipleura, and with moderately dense, greyish hairs. First tergite ca  $2.3\times$  as long as its apical width; glymma relatively small, shallow; dorsomedian carina of first tergite very weak, hardly discernible. Second tergite about  $0.9\times$  as long as its apical width; thyridium relatively small, oval, its distance from basal margin of tergite slightly longer than its length. Epipleurum of second and third tergites separated by a crease. Third and following tergites

wider than long, posterior margins medially not excised. Ovipositor sheath 1.25× as long as first tergite, in lateral view parallel-sided, medially not widened, ovipositor weakly upcurved in basal two-third, distinctly upcurved in apical third, dorsal preapical part shallowly concave without distinct teeth, tip acute.

*Colour.* Antenna black. Head black except palpi and mandibles medially reddish brown, mandibular teeth brown. Mesosoma black, tegula blackish to dark brownish. Metasoma black, posterior margins of apical tergites narrowly, rather indistinctly reddish-brown. Wings hyaline, wing veins brown, pterostigma brownish, along its anterior margin dark brown. Legs: coxae, trochanters, trochantelli black; femora almost entirely black, apically narrowly ferruginous (rust-coloured); tibiae entirely ferruginous; tarsi ferruginous, apical tarsomeres brownish.

*Male.* Unknown.

*Distribution.* Mongolia.

*Etymology.* The specific epithet is the feminine form of the Latin adjective *atrox* meaning frightening, fierce, heinous; it refers to the dark, dreadful general habitus of the new species.

*Remarks on identification.* By using the identification key published by Horstmann (2004), *Lathrostizus atrox* sp. nov. might key out with *Lathrostizus alpinus* at couplet 12, however, it already fails to show complete match to the second half of couplet 10 regarding colouration of hind tibia. The distinctive characteristics from *Lathrostizus alpinus* are given in the Diagnosis section.

### ***Phobocampe Förster, 1869***

*Type species.* *Campoplex crassiusculus* Graenicher, 1829; designation by Viereck (1914).

### ***Phobocampe kaszabi* sp. nov.**

(Figures 3–5)

*Material examined.* Holotype: female, Mongolia, Čojbalsan aimak, 20 km SW v. Somon Bajan-

uul, 820m, 18.VIII.1965, leg. Z. Kaszab (Nr. 444); specimen card-mounted; Id. No. HNHM-HYM 153174. – The holotype is deposited in the Hymenoptera Collection of HNHM (Budapest, Hungary).

*Diagnosis.* The new species can be distinguished from all known *Phobocampe* species by the following characters in combination: gena short, strongly narrowed behind eyes; malar space 0.3–0.4× as long as basal width of mandible; mesosoma, including speculum, entirely granulate without discernible punctures; area superomedia at the level of costulae 2× as wide as its length above the level of costulae; lateromedian longitudinal carinae behind costulae shortly convergent then widely divergent; area superomedia and area petiolaris granulate without distinct wrinkles; propodeal spiracle short oval, separated from pleural carina by 1.2× its greatest diameter; posterior transverse carina of mesosternum weakened, almost interrupted before middle coxae, laterally and medially present, medially rather strongly excised; glymma small, very shallow; first tergite with distinct dorsomedian carina over its entire length; postpetiolus wider than long in dorsal view; second tergite 0.95× as long as its apical width; ovipositor sheath shorter than apical depth of metasoma; areolet small, petiolate; lower external angle of second discal cell almost right-angled; hind coxa entirely reddish; hind femur reddish, apically narrowly darkened; hind tibia basally and apically relatively narrowly dark brownish, externo-medially ivory, interno-medially reddish; metasoma blackish except second tergite dark brownish with reddish band on apical half and third tergite dark brownish with reddish brown lateral patches. *Phobocampe kaszabi* sp. nov. is most similar to the Western Palaearctic species *Phobocampe pulchella* (Thomson, 1887), which differs from the new species by the following characters: area superomedia wider (at the level of costulae about 2.5× as wide as its length above the level of costulae) and behind costulae distinctly longer with parallel or subparallel lateral carinae; area superomedia apically and area petiolaris with weak but distinct wrinkles; propodeal spiracle oval, separated from pleural carina



Figures 3–5. Holotype of *Phobocampe kaszabi* sp. nov., female. 3 = lateral habitus; 4 = wings, dorsal view; 5 = propodeal carination, dorsal view (only carinae are depicted, other surface structures not).

by distinctly less than its greatest diameter; posterior transverse carina of mesosternum complete and slightly elevated along entire length, medially only slightly excised; lower external angle of second discal cell distinctly acute; speculum ventrally more or less shinier, subpolished; third tergite brown to reddish brown without distinct lateral reddish patches.

*Description.* Female (Figs 3–5). Body length *ca* 5 mm, fore wing length *ca* 4 mm.

*Head.* Antenna with 25 flagellomeres; first flagellomere slender, *ca* 3 $\times$  as long as its apical width; preapical flagellomeres little longer than wide. Head transverse, granulate, and with relatively long whitish hairs. Ocular-ocellar distance slightly shorter than ocellus diameter, posterior ocellar distance *ca* 1.5 $\times$  as long as ocellus diameter. Inner eye orbits slightly indented, ventrally weakly convergent. Gena (temple) more finely granulate than other parts of head with scattered, very weak, indistinct punctures, short, strongly narrowed behind eye, in dorsal view about 0.35 $\times$  as long as eye width. Occipital carina complete, reaching hypostomal carina little before mandibular base; hypostomal carina not elevated. Malar space short, 0.3–0.4 $\times$  as long as basal width of mandible. Face and clypeus flat in profile, mode-

rately coarsely granulate, matt, maximum face width about 0.8 $\times$  as wide as frons below middle ocellus. Clypeus weakly separated from face, with weak subapical groove, apical margin sharp, shiny, very weakly convex, medially truncate. Lower margin of mandible with wide flange from teeth toward base, upper mandibular tooth slightly longer and higher than lower tooth.

*Mesosoma.* Mesosoma granulate without discernible punctures, and with short, whitish-greyish hairs, hairs denser on dorsal parts than on lateral parts. Pronotum with relatively weak wrinkles on lower half; epomia distinct. Mesoscutum moderately coarsely granulate, convex in profile, slightly wider than long; notaulus not developed. Scutellum convex in profile, without lateral carina. Mesopleuron, including speculum, granulate, with a few, indistinct diagonal wrinkles anterodorsal to speculum; mesopleuron postero-medially, below speculum, impressed; mesopleural suture rather deep with strong, short transverse costae. Pleural and ventral part of epicnemial carina complete, strong, not elevated; transverse part (*i.e.* part at the level of sternaulus running through the epicnemium to the ventral edge of pronotum) absent; pleural part obliquely bent to anterior margin of mesopleuron reaching it below its middle height. Sternaulus indistinct.

Posterior transverse carina of mesosternum weakened, almost interrupted before each middle coxae, laterally and medially present, slightly elevated, medially rather strongly excised. Metanotum finely granulate, short, about 0.4× as long as scutellum. Metapleuron granulate; juxtacoxal carina absent; submetapleural carina complete. Pleural carina of propodeum strong; propodeal spiracle short oval, separated from pleural carina by 1.2× its greatest diameter, spiracle connected to pleural carina by a distinct ridge. Propodeum short, entirely granulate without distinct wrinkles; propodeal carinae distinct. Costula (section of anterior transverse carina between lateromedian and lateral longitudinal carinae) strong, complete, connecting to lateral margin of area superomedia behind its middle. Lateromedian longitudinal carinae behind costulae shortly convergent, this convergent part slightly weaker than other parts of carinae, then widely divergent, then at extreme apex convergent. Area basalis triangular, longer than its basal width, its lateral carinae weak. Area superomedia basally triangular, wide, at the level of costulae 2× as wide as its length above the level of costulae; area superomedia below costulae shortly constricted, apically opened, confluent with area petiolaris. Fore wing with small, petiolate areolet, second recurrent vein (*2m-cu*) distinctly distal to its middle, *3rs-m* pigmented; distal abscissa of *Rs* straight; distal half of distal abscissa of *M* weakly pigmented; anterior half of second recurrent vein (*2m-cu*) slightly bent inward; nervulus (*cu-a*) postfurcal by about 0.35× its length, inclivous; postnervulus (abscissa of *Cu1* between *1m-cu* and *Cu1a* + *Cu1b*) intercepted slightly below its middle by *Cu1a*; lower external angle of second discal cell almost right-angled (*ca* 86°). Hind wing with nervellus (*cu-a* + abscissa of *Cu1* between *M* and *cu-a*) weakly inclivous, not intercepted; discoidella (distal abscissa of *Cu1*) not connected to nervellus, spectral. Coxae finely granulate. Hind femur relatively stout, *ca* 4× as long as high. Inner spur of hind tibia distinctly longer than outer spur, inner spur *ca* 0.65× as long as hind basitarsus. Hind basitarsus without a midventral row of closely spaced, short hairs. Tarsal claws small, slightly shorter than arolium, with few weak, indistinct basal pecten.

*Metasoma.* Metasoma finely granulate to coriaceous, with dense, whitish-greyish hairs. First tergite relatively stout, *ca* 2.2× as long as its apical width, in dorsal view distinctly widened from basal third toward apex, in lateral view its convex, swollen apical part distinctly longer than flat basal part; glymma small and very shallow; first tergite with distinct dorsomedian carina over its entire length; postpetiolus wider than long in dorsal view (length measured from spiracle to apical margin), its lateral sides convex. Second tergite about 0.95× as long as its apical width; thyridium large, oval, its distance from basal margin of tergite slightly less than its length. Epipleurum of second and third tergites separated by a crease. Third and following tergites wider than long, posterior margins medially not excised. Ovipositor short, its sheath shorter than apical depth of metasoma, in lateral view apically widened.

*Colour.* Antenna dorsally brown, ventrally light brown, scapus and pedicellus ventrally yellowish to yellowish brown. Head black except yellowish palpi and mandibles, mandibular teeth reddish brown. Mesosoma black except pale yellow tegula. Metasoma: first tergite blackish to dark brownish, apical margin very narrowly, indistinctly paler; second tergite dark brownish with pale reddish band on apical half; third tergite dark brownish with pale reddish brown lateral patches; fourth and following tergites blackish; ovipositor sheath brown. Wings hyaline, wing veins and pterostigma brown. Fore and middle legs: coxae reddish yellow; trochanters and trochantelli pale yellowish; femora reddish yellow; tibiae reddish yellow, externo-medially pale yellowish; tarsi yellowish, apical tarsomeres brownish. Hind leg: coxa entirely reddish; trochanter and trochantellus pale yellowish; hind femur reddish, apically narrowly darkened; hind tibia externo-medially ivory, interno-medially reddish, its basal 0.15 and apical 0.2 brownish; tarsus brownish, basal 0.7 of basitarsus yellowish.

*Male.* Unknown.

*Distribution.* Mongolia.

*Etymology.* This species is dedicated to the memory of Dr. Zoltán Kaszab (1915–1986),

former curator of Coleoptera Collection and general director of Hungarian Natural History Museum (Budapest), in honour of his remarkable collecting activity during his one-man collecting trips in Mongolia between 1963–1968.

*Remarks on identification.* By using the identification key of the revision of Western Palaearctic *Phobocampe* species (Šedivý 2004), *Phobocampe kaszabi* sp. nov. might key out with *Phobocampe pulchella* (Thomson, 1887) or, given that the efficient use of that key requires some experience, either with *Phobocampe crassiuscula* (Gravenhorst, 1829) or with *Phobocampe uncinata* (Gravenhorst, 1829). The distinctive characteristics from the most similar species, *Phobocampe pulchella*, are given in the Diagnosis section. Both other species can be readily distinguished from the new species as follows: *Phobocampe crassiuscula* by its dark hind coxa, and *Phobocampe uncinata* by its elongated (usually longer than wide or rarely quadratic) postpetiolus and wider area superomedia (at the level of costulae about 2.5–3× as wide as its length above the level of costulae).

## Faunistics

### Campopleginae Förster, 1869

#### *Clypeoplex cerophagus* (Gravenhorst, 1829)

*Material.* Bulgaria, Sofia, Vitosha Mts., 1000 m, 3.VIII.1982, leg. Á. Draskovits & Á. Vály, 1♀.

*Remarks.* First record for Bulgaria. This species is widely distributed in the Palaearctic region (Yu *et al.* 2012).

#### *Phobocampe brumatae* Horstmann, 2009

*Material.* Hungary, Veszprém County, Szigliget, 20–22.IV.2019, leg. Z. Vas, 1♂.

*Remarks.* First record for Hungary. This species has been known from France and the United Kingdom so far (Horstmann 2009, Yu *et al.* 2012).

#### *Phobocampe pulchella* (Thomson, 1887)

*Material.* Hungary, Pest County, Páty, Mézes-hegy, 17–25.VI.2018, leg. Z. Vas, 1♀.

*Remarks.* First record for Hungary. This species is known from several European countries (Horstmann 2008, Yu *et al.* 2012).

#### *Phobocampe quercus* Horstmann, 2008

*Material.* Hungary, Pest County, Törökbálint, collected at 13.V.2019 as cocoon, adult wasp emerged at 6.VI.2019, leg. S. Nagy, 1♀.

*Remarks.* First record for Hungary. This species has been known from Germany, Poland, Spain and United Kingdom so far (Horstmann 2008, Yu *et al.* 2012).

### Cryptinae Förster, 1869

#### *Thaumtogelis lichtensteini* (Pfankuch, 1913)

*Material.* Moldova, Rîșcani District, Vărativ, 9.VII.2018, leg. A. I. Csathó, 1♀.

*Remarks.* First record for Moldova. This species is widely distributed in the Western Palaearctic region (Schwarz 2001, Yu *et al.* 2012, Vas & Schwarz 2018).

### Hybrizontinae Förster, 1869

#### *Ghilaromma ussuriensis* Tobias, 1988

*Material.* North Korea [on label: Korea], Ryang-gang Province, Hyesan, Mt. Ze-dong, 1150m, 26.VII.1975, leg. J. Papp & A. Vojnits, 4♂.

*Remarks.* First record for North Korea. This species has been known from East Russia (Primorsky-Krai) (Yu *et al.* 2012, Konishi *et al.* 2012).

#### *Hybrizon buccatus* (Brebisson, 1825)

*Material.* Serbia, Petrovaradin [on label: Pétervárad], 6.VII.1892, leg. unknown, 1♀. – Kosovo,

Peć [on label: Ípek], 27.VI.1917, leg. E. Csiki, 1♀. – Romania, Cluj County, Ocna Dejului [on label: Désakna], date unknow, leg. E. Zilahi-Kiss, 3♀; Bistrița-Năsăud County, Coldău [on label: Kudu], date unknow, leg. E. Zilahi-Kiss, 1♀; Mureș County, Socata [on label: Szováta], date unknow, leg. E. Csiki, 3♀; Sălaj County, Cehu Silvaniei [on label: Szilágycseh], date unknow, leg. E. Zilahi-Kiss, 1♀; Satu Mare County, Hodod [on label: Hadad], 1904, leg. E. Zilahi-Kiss, 1♀; Cluj County, Comuna Chiuiiești [on label: Pecsétszeg], VIII.1911, leg. unknown, 1♀; Satu Mare County, Tășnad [on label: Tasnád], VII. 1912, leg. L. Bíró, 1♀; Alba County, Aiud [on label: Nagyenyed], 20.VIII.1918, leg. Z. Szilády, 1♀; Harghita County, Odorheiu Secuiesc [on label: Székelyudvarhely], 19.IX.1919, leg. Z. Szilády, 1♀; Arad County, Ineu [on label: Borosjenő], 31.V.1922, leg. Diószeghy, 1♀. – North Korea [on label: Korea], Ryang-gang Province, Plateau Chann-Pay Sam-zi-yan, 1600m, 25–28.VIII.1971, leg. S. Horvatovich & J. Papp, 4♀; Pyongyang, VIII–IX.1971, leg. S. Horvatovich & J. Papp, 10♀.

*Remarks.* First records for Serbia, Kosovo, Romania and North Korea. This species is widely distributed in the Palaearctic region (Yu *et al.* 2012).

#### ***Hybrizon ghilarovi* Tobias, 1988**

*Material.* Germany, Dubrow, 7.VII.1965, leg. J. Oehlke, 1♂.

*Remarks.* First record for Germany. This species has been known from Bulgaria, China, and Far East Russia (Yu *et al.* 2012, Konishi *et al.* 2012, Achterberg *et al.* 2013).

#### ***Hybrizon pilialatus* Tobias, 1988**

*Material.* Romania, Sălaj County, Crasna, 14.IX.1982, leg. Andriescu, 4♂.

*Remarks.* First record for Romania. This Western Palaearctic species has been reported from Austria, Bulgaria, Czech Republic, Germany, Hungary, Italy, Poland and Russia (Kostroma

Oblast) so far (Achterberg 1999, Yu *et al.* 2012, Mandl 2017, Vas & Bakardzsiev 2019).

#### **Subfamily: Tersilochinae Förster, 1869**

##### ***Probles (Euporizon) truncorum* (Holmgren, 1860)**

*Material.* Hungary, Pest County, Dömsöd, 7–8.VI.2019, leg. L. Ronkay, M. Ronkayné Tóth & Z. Vas, at light, 1♀.

*Remarks.* First record for Hungary. This species is widely distributed in the Western Palaearctic region (Yu *et al.* 2012).

##### ***Tersilochus (Tersilochus) obliquus* (Thomson, 1889)**

*Material.* Hungary, Fejér County, Bicske, 20.IV.2019, leg. K. Bakardzsiev, 1♀.

*Remarks.* First record for Hungary. This species has been known from several European countries so far (Yu *et al.* 2012).

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## New records for the genus *Grammacephalus* Haupt (Hemiptera: Auchenorrhyncha: Cicadellidae)

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**Abstract.** *Grammacephalus rahmani* Singh Pruthi, 1930 is recorded for the first time from the United Arab Emirates and Mali, *G. raunoi* Viraktamath, 1981 – from the United Arab Emirates, and *G. indicus* Viraktamath et Ananta Murthy, 1999 – from Afghanistan. Photos of these species are provided, and male genitalia of *G. rahmani* and female 7<sup>th</sup> sternite of *G. indicus* are illustrated. Distribution and composition of the genus *Grammacephalus* Haupt is discussed.

**Keywords.** Deltocephalinae, Scaphoideini, morphology, new record, distribution, Middle East, Western Africa.

During my study of the leafhopper genus *Grammacephalus* Haupt, 1929 (Deltocephalinae, Scaphoideini) new records are registered for *G. rahmani* Singh Pruthi, 1930 from the United Arab Emirates and Mali, for *G. raunoi* Viraktamath, 1981 from the United Arab Emirates, and for *G. indicus* Viraktamath & Ananta Murthy, 1999 from Afghanistan.

According to the recently published revision of the genus *Grammacephalus* by Shah *et al.* (2019) it comprises 13 species distributed from India via Middle East to Africa including Cape Verde. However, Dlabola's (1980) record of *G. pugio* (Noualhier, 1895) (listed as *G. turneri* (Evans, 1947) a junior synonym of *G. pugio* according to Dlabola (1960)) from Saudi Arabia (Wadi Tihamma) was missed from this revision. According to my data the genus is also present in the United Arab Emirates, Mali, and Afghanistan. These new records are listed below.

### MATERIAL AND METHODS

The study based on the specimens deposited in the collection of the Zoological Institute of the

Russian Academy of Sciences, Saint Petersburg (Russia), collected between 1966 and 2010.

The photographs of the specimens were taken using the microscope Leica MZ9.5 and a Leica DFC 490 camera. Images were produced using Helicon Focus V. 6.7.1 and Adobe Photoshop software. The drawings were prepared using the same microscope with camera lucida attached.

### RESULTS AND DISCUSSION

#### *Grammacephalus indicus* Viraktamath & Anantha Murthy, 1999

(Figures 1, 2, 12, 17)

*Grammacephalus indicus* Viraktamath et Anantha Murthy, 1999: 42, figs 14–21.

*Material examined.* Afghanistan: 2♂, 1♀, Nangarkhar Province, Djalalabad, Kabul River, 22.VII.1966, E.S. Sugonyaev leg.

*Remarks.* The species was described from New Delhi in India (Viraktamath & Anantha Murthy 1999) and later recorded from Sindh and Punjab Provinces in Pakistan (Khatri & Webb 2010; Naveed & Zhang 2018).



**Figures 1–4.** *Grammacephalus* spp. 1 = *G. indicus*, male (Afghanistan), dorsal view; 2 = same, lateral view; 3 = *G. raunoi*, female (UAE), dorsal view; 4 = same, lateral view. Male – 4.5 mm. Female – 5.0 mm.

Male genitalia of the specimen from Afghanistan were examined and compared with the drawings by Viraktamath & Anantha Murthy (1999, figs 14–21) and Khatri & Webb (2010, figs 20, 21) and the photos by Naveed & Zhang (2018, fig. 1) with no significant differences discovered. From the other hand the hind margin of female 7<sup>th</sup> sternite illustrated by Khatri & Webb (2010, fig. 20c) is widely concave while the female from Djalalabad has it sharply notched medially (Fig. 12), wherein Viraktamath & Anantha Murthy (1999: 42) noticed in the original description of *G. indicus* that 7<sup>th</sup> sternite of this species has V-shaped excavation on its hind margin which is in accordance to the condition of the specimen from Afghanistan examined by the author (Fig. 12), confirmed also by the photo of female paratype of *G. indicus* kindly sent for my study by Dr. Chandrashekharaswamy A. Viraktamath (Bangalore, India). Thus Khatri & Webb (2010) apparently figured female 7<sup>th</sup> sternite of another species, different from *G. indicus*, erroneously reproduced again by Shah et al (2019, fig. 5D).

***Grammacephalus raunoi* Viraktamath, 1981**

(Figures 3, 4, 16)

*Grammacephalus raunoi* Viraktamath, 1981: 9, figs 30–36.

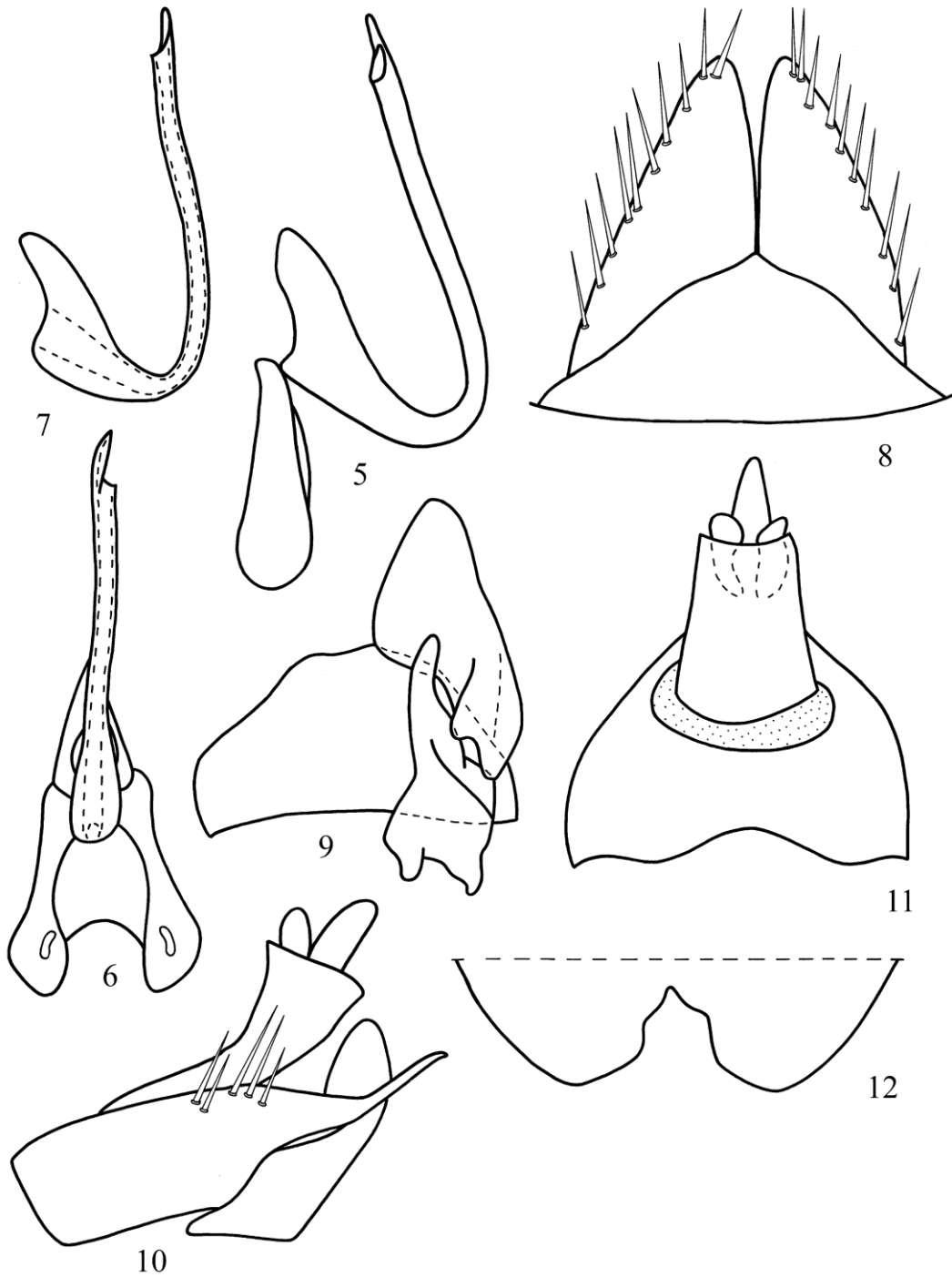
*Material examined.* United Arab Emirates: 1♂, 2♀, Sharjah, Sharjah Desert Park, N 25°16.859' E 55°41.422', 17.IV.2010, at light, V.M. Gnezdilov leg.

*Note.* The species was described from Delhi in India (Viraktamath 1981) and later recorded from Punjab (Mianwali) in Pakistan (Naveed & Zhang 2018). In UAE the species was collected in sand desert near to park house at light during the evening from 20.00 to 20.30.

***Grammacephalus rahmani* (Singh Pruthi, 1930)**

(Figures 5–11, 13–15)

*Platymetopius rahmani* Singh Pruthi, 1930: 33, figs 45, 46.



**Figures 5–12.** *Grammacephalus* spp. 5–11 = *G. rahmani*. 12 = *G. indicus* (Afghanistan). 5 = aedeagus and connective, lateral view (specimen from Mali); 6 = same, dorsal view; 7 = aedeagus, lateral view (here and following numbers – specimens from UAE); 8 = valve and subgenital plates, ventral view; 9 = valve, style, and subgenital plate, dorsal view; 10 = male pygofer, subgenital plate, and anal tube, lateral view; 11 = male pygofer and anal tube, dorsal view; 12 = female 7<sup>th</sup> sternite, ventral view.

*Material examined.* United Arab Emirates: 5♂, Sharjah, Sharjah Desert Park, N 25°16.859' E 55°41.422', 13.IV.2010, V.M. Gnezdilov leg. Mali: 1♂, Kita, 20.XII.1969, Orlovskaya leg.

*Remarks.* The species was described from Lyallpur (currently Faisalabad) in Punjab of Pakistan where it was collected at light (Singh Pruthi 1930). Later it was recorded from Sindh Province in Pakistan (Mahmood 1979, after Khatri & Webb 2010) and from India (Delhi, Gujarat, Jammu and Kashmir, Karnataka, Punjab) (Viraktamath 1981). In UAE the species was collected in sand desert during the day sweeping *Prosopis cineraria* (L.) Druce (Fabaceae).

Male genitalia of the species were illustrated by Singh Pruthi (1930, fig. 46) and later by Viraktamath (1981, figs. 2–8) based on the specimens from the Indian subcontinent. Viraktamath (1981: 8) suggested that *G. rahmani* could be conspecific with *G. turneri* (Evans, 1947), however, the latter is distinguished by sinuate aedeagal shaft and robust processes of pygofer. From the other hand Dlabola (1960: 17) and following him Shah *et al.* (2019: 81) treated *G. turneri* (Evans) as junior synonym of *G. pugio* (Noualhier) and separated it in the key by aedeagal shaft curved subapically in lateral view.

The specimens from UAE and Mali figured here (Figs 5–11) have aedeagal shaft slightly sinuate in dorsal view, but straight subapically in lateral view, and pygofer with slender processes. My examination of the photo of pygofer process and the aedeagus of *Platymetopius pugio* holotype described from Akbès (Alep) in Northern Syria (Puton & Noualhier 1895), deposited in the Museum national d' Histoire naturelle (Paris, France) and kindly sent for study by Dr. A. Soulier-Perkins, showed their identity with Linnavuori's figures (Linnavuori 1978, figs. 12f, 13a) reproduced by Shah *et al.* (2019). Apparently, for solving the question on possible synonymy of the mentioned names it will be necessary to examine the type specimen of *G. turneri* and compare it with *G. pugio* and *G. rahmani*. Currently, I am identifying the material from UAE and Mali as *G.*

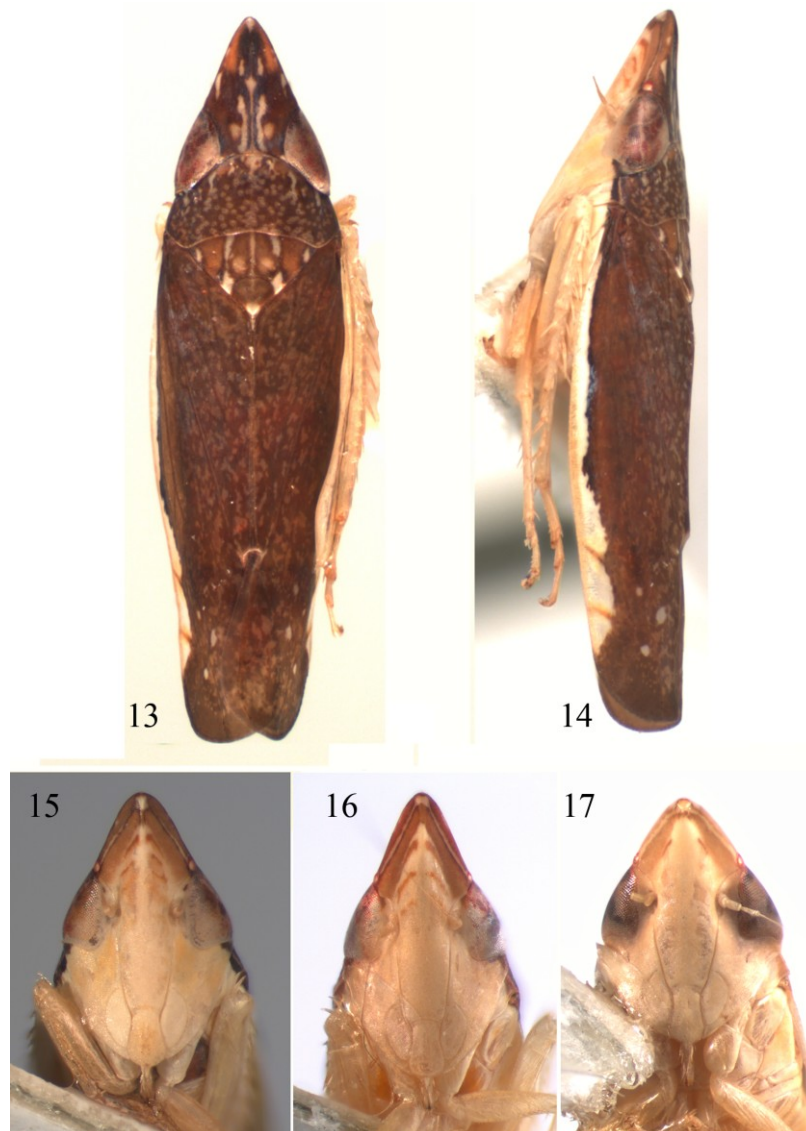
*rahmani* insofar as this species is well defined and illustrated.

## CONCLUSIONS

*Grammacephalus rahmani* together with *G. raunoi* are first records of the tribe Scaphoideini Oman, 1943 from the United Arab Emirates as herein the subfamily Deltocephalinae Dallas was known from UAE only after few species of the tribes Chiasmini Distant, Eupelicini Sahlberg, and Macrostelini Kirkaldy (Wilson & Turner 2010, Gnezdilov 2019).

Linnavuori (1978: 476) assumed that the genus *Grammacephalus* radiated from Africa to the Oriental region "...along the mountain ranges bordering the Red Sea...". However, according to current data within 13 described species of the genus 8–9 species are known from the Oriental region (7 – from Indian subcontinent, one – from southern China, and one unidentified species – from the Philippines (Webb & Godoy 1993)), 7 species – from Africa and Arabian Peninsula, and 3 species – from Iran. Probably *Grammacephalus* species have no particular host-plant specialization as different species are recorded from several plant families including Fabaceae, Rhamnaceae, and Sapindaceae (Viraktamath 1981; Dai *et al.* 2006, current data). Insofar as the species of *Grammacephalus* may easily fly for long distance we can not confidently locate the centre of diversification of this genus. Apparently, some species currently known as local endemics would be found later in other regions as it is demonstrated here for *G. rahmani* and *G. raunoi*.

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Figures 13–17. *Grammacephalus* spp. 13–15 = *G. rahmani*, male – 4.5 mm (UAE). 16 = *G. raunoi*, female (UAE). 17 = *G. indicus*, male (Afghanistan). 13 = dorsal view; 14 = lateral view; 15–17 = face.

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# Der Regenwurm *Dendrobaena illyrica* (Cognetti, 1906) an der nördlichen und nordwestlichen Grenze seiner Verbreitung (Oligochaeta: Lumbricidae)

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**Abstract.** The earthworm *Dendrobaena illyrica* (Cognetti, 1906) on the northern and northwestern boundary of its distribution (Oligochaeta: Lumbricidae). The northern and northwestern boundary of the range of *Dendrobaena illyrica* (Cognetti, 1906), which runs through the eastern part of the edge of the Central European Uplands, is here more precisely determined on the basis of new localities. The species has been found in areas of the Böhmerwald/Bayerischer Wald, Oberpfälzer Wald, Fichtelgebirge, Vogtland, Erzgebirge and Elbsandsteingebirge. On the northern slope of the Erzgebirge, the range boundary corresponds to the 'flint line' marking the margin of the first Elsterian Cold Period glaciation. This earthworm species prefers forest soils formed on acidic magmatites and metamorphites as source rocks. We found both fully developed individuals of the species which reproduce sexually, and externally not fully developed adult individuals which we classed as the parthenogenetic form of the species. The distribution of both forms shows that parthenogenesis appears to occur geographically in *D. illyrica*, i.e. the sexual form predominates in optimal habitats near the core of the range, while the parthenogenetic form occurs in less favourable habitats and at the edges of the range.

**Keywords.** Earthworms, *Dendrobaena illyrica*, Germany, new records, boundary of distribution, parthenogenesis.

## EINLEITUNG

Bei den gut und gleichmäßig durchforschten Arten von Vertebraten, Insekten und höheren Blütenpflanzen sind fundierte Grenzen ihrer Areale ermittelt worden (de Lattin 1967, Müller 1977). Weniger günstig ist die Situation bei einigen Regenwurmart, bei denen es noch zahlreicher einwandfreier faunistischer Unterlagen bedarf, um anhand von Fundpunkten Arealgrenzen feststellen zu können. Zu diesen Arten gehört *Dendrobaena illyrica* (Cognetti, 1906), von der angenommen wird (Lehmitz *et al.* 2016), sie sei in Deutschland extrem selten. Bisher sind in der faunistischen Literatur deutsche Funde der Art aus dem Bayerischen Wald/Hohen Böhmerwald (Michaelson 1907), dem Oberpfälzer Wald (Makeschin 1983, 1987, Makeschin & Beck 1986), dem westlichen Erzgebirge (Kollmannsperger 1936) und dem Osterzgebirge (Bösener 1964, 1965, La France 2002) bekannt. Zahlreiche Funde gibt es im angrenzenden tschechischen

Gebiet (z.B. Pižl 2001, 2002 a, b, Švarc & Kula 2011, Kula & Švarc 2012), wo *D. illyrica* in den Bergmischwäldern des Erzgebirges und Böhmerwaldes eine sub- bis eudominante Regenwurmart ist. Sie entspricht dem illyrischen Verbreitungstyp und wurde bisher in Deutschland, Tschechien, Österreich, Kroatien, Bosnien-Herzegowina, Montenegro, Serbien und Mazedonien nachgewiesen (Csuzdi *et al.* 2011, Szederjesi 2017; Abb. 1). Im vorliegenden Beitrag werden neue deutsche Funde und einige Beobachtungen zur Populationsstruktur der Art mitgeteilt.

## MATERIAL UND METHODEN

### Untersuchungsgebiet

Wir untersuchten Waldstandorte westlich der Elbe, so im Elbsandsteingebirge, Erzgebirgsvorland, Erzgebirge, Vogtland, Thüringer Schiefergebirge, Frankenwald, Fichtelgebirge, Oberpfälzer Wald und Bayerischen Wald, die sämtlich



Abbildung 1. Die Verbreitung von *Dendrobaena illyrica* (Cognetti, 1906).

in Höhenlagen von mehr als 230 m ü. NN, meist höher als 400 m ü. NN im herzynisch-sudetischen Bergmischwaldgebiet (Freitag 1962) liegen. Die geprüften Bodenstandorte befinden sich in der natürlichen Zone der montanen und kollin-submontanen Buchenmischwälder (Firbas 1949, Walter & Straka 1970) und im angrenzenden Randbereich der Eichen-Buchenwaldzone (Schmidt *et al.* 2002). Sporadisch untersucht wurden auch Standorte in den Nachbargebieten dieser Zone. Das betrachtete Untersuchungsgebiet, das ein Teil der östlichen mitteleuropäischen Mittelgebirgsschwelle ist, umfasst ca. 50 000 km<sup>2</sup>.

### Methodik

Hauptsächlich wurde die nordwestliche und nördliche Grenze des Areals von *D. illyrica* gesucht. Ausgehend von den bisher in der Literatur genannten Fundorten prüften wir deshalb vorwiegend in radialer Richtung weitere Bodenstandorte, um so an die Grenze des Areals der Art zu gelangen. Auf diese Weise wurden entlang der nördlichen Verbreitungsgrenze Standorte im Abstand von ca. 2 bis 10 km untersucht, an denen die Art vorkam oder fehlte. Selbstverständlich ist daher die Anzahl der Fundpunkte mitbestimmt vom Aufwand, diese Grenze zu finden. Um *D. illyrica* an einem Standort nachzuweisen, wurden

0,25 m<sup>2</sup> große Flächen genau geprüft, die überwiegend in der Regentraufe von Bäumen, an Hangfüßen oder in flachen Dellen mit etwas erhöhter Bodenfeuchte lagen. Zumeist waren es einzelne derartige Untersuchungsflächen, in einigen Fällen wurden zwei bis drei Flächen entlang eines Transekts untersucht. Bis in eine Tiefe von 0,3 m wurden alle Regenwürmer ausgegraben und in zweimaliger Durchsicht des Bodens von Hand ausgelesen. Die beim Ausgraben hergestellte Schürfgrube diente der Bodenansprache. Merkmale des Bodenprofils, der Geländemorphologie und der Vegetation des untersuchten Bodenstandorts wurden vor Ort protokolliert. Die Belege der gefundenen Regenwürmer befinden sich in der Sammlung des Autors.

## ERGEBNISSE

### Das Verbreitungsbild der Art anhand der Verteilung der Fundpunkte

Der Autor sammelte an 126 Fundpunkten 380 Individuen von *D. illyrica*. Auf den 0,25 m<sup>2</sup> großen Bodenflächen dieser Fundpunkte konnten überwiegend einzelne, aber maximal 15 Individuen dieser Art festgestellt werden. *D. illyrica* wurde in Wäldern des östlichen Teils der Mitteleuropäischen Mittelgebirgsschwelle gefunden, nämlich am Südrand des mitteleuropäischen Mulde-Lösshügellandes, im Elbsandsteingebirge, Erzgebirge, Erzgebirgsbecken, Vogtland einschließlich Ostthüringer Schiefergebirge und Elstergebirge, im Fichtelgebirge, Oberpfälzer Wald und Böhmerwald/Bayerischen Wald. Ungefähr auf einem Drittel aller in diesem Gebiet nach genannter Methode untersuchten Bodenstandorte kamen Nachweise der Art zustande. Dieses Ergebnis und die geographische Verteilung der von uns ermittelten Fundpunkte zeigen, dass im untersuchten Teil des Art-Areals sehr große, arealgliedernde Verbreitungslücken anscheinend nicht bestehen (Abb. 2). Somit ist davon auszugehen, dass *D. illyrica* in einem kontinuierlichen Areal vorkommt. Entlang der nördlichen Arealgrenze wurde eine Reihe von Fundpunkten ermittelt, die sich in kleineren und fleckenartig verteilten Waldhabitaten befinden.



Abbildung 2. Der nördliche und nordwestliche Rand des Areal von *Dendrobaena illyrica* in Deutschland.

Keine Nachweise ergaben sich im Thüringer Schiefergebirge, im Frankenwald und auf der Münchberger Hochfläche, die nach gegenwärtiger Kenntnis vor dem Westrand des Areal liegen.

### Die nördliche und nordwestliche Verbreitungsgrenze

An der Nordabdachung des Erzgebirges verläuft die anhand unserer Funde ermittelte Nordgrenze der Verbreitung von *D. illyrica* auf ca. 120 km Strecke zwischen Weißer Elster und Elbe annähernd deckungsgleich mit der Feuersteinlinie, die in Pietzsch (1962), Wagenbreth (1978), Eissmann (1994), Wolf & Alexowsky (2008) und Ehlers (2011) annähernd gleich dargestellt ist. Diese Linie markiert den Rand der maximalen Elster-1-Kaltzeit-Vergletscherung, an der Zwickauer Mulde den Elster-2-Eisvorstoß. Mehrere nordwärts vorgeschobene Fundpunkte der Art entsprechen den Vorsprüngen der Feuersteinlinie, so im Hofholz bei Endschütz (4374), Trünziger Wald bei Wolframsdorf (4275), Jahnsborn bei Niederfrohna (4121), Viehwegbusch bei Bockendorf (4400) und Tharandter Wald bei Grund (4347). Diese Ergebnisse sprechen für eine Beziehung von *D. illyrica* zur Verwitterungsdecke, die sich im gletscherfreien Periglazial-

gebiet südlich der maximalen Kontinentalvereisung entwickeln und dort Grundlage der Bodenbildung sein konnte. Bei Zwickau und bei Chemnitz weicht die nördliche Arealgrenze in jeweils auffälliger Bucht deutlich südwärts zurück, was ebenfalls dem Verlauf der Feuersteinlinie entspricht. Dergestalt blieben Funde der Art im Rumpfwald bei Zwickau aus. Auch in der paarigen Chemnitzer Bucht wurde die Art vielerorts nicht nachgewiesen: So ist im südwestlichen Teil dieser Bucht z.B. der Steegenwald und nordwestliche Hauwald, andererseits im südöstlichen der Abtwald ohne bisherige Funde.

Das nordwestliche Stück der Arealgrenze der Art verlässt die Feuersteinlinie westlich der Weißen Elster, bei Weida, und nimmt seinen weiteren Verlauf im Ostthüringer Schiefergebirge in südwestlicher Richtung am Westrand des Vogtlandes, ungefähr bei Triebes, Zeulenroda, Schleiz, also am Rande der Ziegenrucker Mulde, und erreicht bei Burgk die Saale. Im südwestlichen Vogtland verläuft die Verbreitungsgrenze von der Saale nach Südosten, durch den Kämmerawald bei Tanna und ostwärts über das Eichigt/Birkigt bei Rößnitz bis zur Weißen Elster bei Plauen. Südwärts über Oelsnitz/ Vogtl. erreicht sie südlich von Triebel/ Vogtl. den Schirningwald und bei Rehau das nördliche Fichtelgebirge. Weiter südwärts durchquert die Arealgrenze das Fichtelgebirge und verläuft entlang des Oberpfälzer Waldes. Der von uns ermittelte westlichste deutsche Fundort der Art ist der Burgkwald an der Oberen Saale (4213). Dieser liegt ca. 45 km weiter westlich als jener, den Makeschin (1987) im Oberpfälzer Wald bei Waldsassen für den westlichsten hielt. Der nordwestlichste der bisherigen Fundpunkte liegt im Schömberger Wald bei Steinsdorf (4375), unweit Weida.

Auf den Talhängen der Zwickauer Mulde tritt die Regenwurmart auch wenig nördlicher als die Feuersteinlinie auf, so ein Stück weit im Gebiet, das vom Gletscherrand erreicht wurde: nördlich von Zwickau (4007, 4014), bei Glauchau (z.B. 3908, 3909, 3913, 3918, 3919), Waldenburg (3920, 3922-3927, 4117, 4118) und Penig (3910-3912, 4327, 4397, 4398). Diese Standorte gehören

offenbar zu Bereichen, in denen viel westerzgebirgisches Verwitterungsmaterial im eiszeitlichen Elster-2-Stadium abgelagert wurde (Wolf & Schubert 1992). Nach jüngster geologischer Kartierung (Alexowsky *et al.* 2007) befinden sich die zwei nördlich von Zwickau nachgewiesenen Vorkommen der Art (4007, 4014) auf tonigem, sandig-kiesigem, braungrauen Schluff des Weichselglazials (aQW) über kryoturbatem elstereiszeitlichem Schluff (gQE2), von dem Altermann *et al.* (2008) zufolge wahrscheinlich beträchtliche Anteile in den Boden eingemischt wurden.

### **Fundpunkt-Verteilung und Bodenausgangsgesteine**

Die Verteilung der Fundpunkte von *D. illyrica* hat auffällig enge Beziehung zur regionalen Verteilung der Bodenausgangsgesteine aus der Gruppe der sauren Magmatite und Metamorphite. Die meisten Fundpunkte befinden sich innerhalb der auf der Karte 2.1.1 in BGR (2016) dargestellten, ums Böhmisches Massiv gruppierten großflächigen Verbreitungsgebiete dieser Ausgangsgesteine. Deutlich gehäuft sind diesbezügliche Fundpunkte am nordwestlichen Rand des Areals der Art, im inselartigen Gebiet des Vorkommens dieser Gesteine zwischen der Oberen Saale bei Schleiz und der Weißen Elster (Mühltruffer Wald, Schwandhölzer, Kettenwald, Köthenwald, Mehltheuerwald, Syrau-Kauschwitzer Heide, Eichigt). In geringerem Maße sind Funde der Art in Böden über Tongesteinen nachgewiesen (z.B. 4004 bei Rödlitz im Erzgebirgsbecken, 4304 bei Leubetha im Vogtland), wo diese an die Vorkommen saurer Magmatite und Metamorphite angrenzen. Daneben gibt es einzelne Funde in Böden über Sandsteinen (z.B. 3239 im Elbsandsteingebirge, 4168 bei Pöllwitz im Vogtland). Nicht angetroffen wurde die Art im Frankenwald, der im Tonschiefer-Gebiet liegt. Offenbar meidet sie das Gebiet basischer Magmatite und Metamorphite. So fehlt sie offensichtlich im Bayerischen Vogtland zwischen Hirschberg und Hof.

### **Körperliche Ausprägung und Populationsstruktur der Art an den Fundorten**

Inmitten des Verbreitungsgebietes von *D. illyrica* wurden äußerlich vollausgeprägte, geschlechtsreife Individuen der Art nachgewiesen, deren männliche Poren des 15. Segments von erhabenen, mächtigen Drüsenhöfen umgeben sind, die beide benachbarte Segmente vollkommen einnehmen. Diesen segmentübergreifenden Drüsenhöfen fehlen die Intersegmentalfurchen. Die vollausgeprägten Tiere tragen auf dem 28. – 34. Segment einen drüsig verdickten, sattelförmigen Gürtel, Pubertätswälle am 31. – 33. und ventral am 29. oder 30. Segment extern adhäsive Spermatophoren. Ihr Anteil an der Gesamtmenge der im untersuchten Gebiet gesammelten erwachsenen Tiere beträgt ~10 Prozent. Sie stammen von *ca.* 20 Prozent der Fundpunkte. Nicht nachweisbar waren derartig ausgeprägte Individuen an zahlreichen Standorten am Rand des Verbreitungsgebietes der Art und in offensichtlich suboptimal ausgestatteten Habitaten, auch z.B. in instabilen Hanglagen (3910–3912) und an möglicherweise gestörten Standorten. Letzteres betrifft z.B. den Bereich der von Kratzsch (1843) genannten Wüstung Reiboldsgrün (4168) mitsamt der umgebenden, *ca.* 15 km<sup>2</sup> großen Waldfläche, die im 17. Jahrhundert für längere Zeit entwaldet war.

Stattdessen wurden hier und in zahlreichen anderen Fällen am Arealrand große erwachsene Tiere der Art gefunden, die allesamt reduzierte äußere reproduktive Strukturen besitzen. Bei vielen Individuen dieser Gruppe treten die deutlichen männlichen Poren des 15. Segments aus einem kleinen flachen bis unauffälligen, aber hofartigen Wall hervor, der stets auf dieses Segment beschränkt ist. Manchmal ist dort ein verdickter Drüsenhof ausgeprägt, der dann aber stets die Segmente 14 und 16 nicht vollkommen einnimmt, zumeist als ein auf das 15. Segment aufgesetzter erscheint oder im Falle von mächtiger Haut-

verdickung um den Porus am Rande des Drüsenhofs von den Intersegmentalfurchen durchzogen ist. Der Gürtel der Tiere dieser Gruppe ist nicht sattelförmig, sondern ein dünnerer, drüsiger Überzug, der im dafür arteigenen Bereich von Segmenten farblich (zumeist dunkler) abgesetzt ist. Bei einigen dieser Tiere ist die Ausdehnung des Gürtels kürzer, indem er das 28. Segment oder jeweils zwei Segmente (28 und 34 oder 33 und 34) nicht einbezieht. Zumeist sind vorhandene Pubertätswälle angedeutet, bei einigen Tieren fehlen sie. Die Fundpunkte, an denen ausschließlich Tiere mit derartig reduzierten äußeren reproduktiven Organen angetroffen wurden, deuten einen Kranz um das Kernareal der Art an.

Neben diesen abweichend ausgeprägten kamen in einzelnen Fällen unter den erwachsenen Tieren desselben Fundpunkts auch äußerlich vollausgeprägte vor (z.B. Neudörfler Wald 4040: 3 von 5; Eichlaide 4397: 1 von 5), die dann stets kleiner waren. Zumeist am Arealrand traten in der Population in überwiegender Mehrzahl Tiere ohne Gürtel und Drüsenhöfe, aber mit undeutlichem männlichen Porushof, d.h. juvenile immature Individuen, traten an wenigen Bodenstandorten auch in Anhäufung auf (z.B. Langer Busch 3910, Schirmingwald 4303).

### Habitat

Alle Individuen der Art wurden als epigäische bis epi-endogäische Lebensformen im Waldboden gefunden, so im organischen Auflagehorizont (L, Of, Oh) und im anschließenden oberen Saum des Mineralischen Oberbodenhorizonts (Ah), der akkumulierten Humus enthält. Auch von Standorten mit geringem Bodenabtrag, teils schmalen Horizonten und temporärer Streuauflage in Hanglage liegen Nachweise der Art vor (z.B. Langer Busch 3910, Oberhang). Die vollausgeprägten, geschlechtsreifen Individuen wurden ausschließlich in Bodenprofilen mit vollständigem Horizont-

spektrum angetroffen, so im Grenzbereich Feinhumus / Ah-Horizont unter geschlossener Streuschicht an Standorten mit stabilem Jahresgang von genug Feuchtigkeit, z.B. in grundfeuchten Böden von Tallagen, oder an der Unterseite von Moosdecken, also im Substrat, das sommerüber sehr lange Feuchtigkeit hält. Die Art kommt sowohl in Böden unter Laubstreu als auch in solchen unter Nadelstreu vor, zumeist auf basenarmen Braunerden (Cambisols) der Mittelgebirgslagen. Die vollausgeprägten geschlechtsreifen Individuen mit sattelförmigen Gürtel fehlten in den *D. illyrica*-Populationen der offensichtlich weniger günstigen Habitate (bei Hanglage, abweichendem Horizontspektrum, Mangel an Laubstreu).

### Funddaten

Im Folgenden werden genannt: Nummer der Untersuchung, Anzahl determinierter Individuen (Ex.) außer juvenilen immaturen, Waldgebiet, örtliche Lage, Koordinaten des Fundorts, Höhenlage, dominierende Baumarten, Funddatum. Die Belege befinden sich in der Sammlung des Autors.

*Böhmerwald/Bayerischer Wald*: 4362: 1 Ex., Zwerchecker Wald, bei Oberhaidenberg, 49°09'54"N, 13°08'26"E, 1010 m, Fichten, Tannen, 10.08.2019. 4363: 1 Ex., Pfefferwald, bei Ottmannszell, 49°10'12"N, 13°00'14"E, 750 m, Fichten, Tannen, 10.08.2019.

*Oberpfälzer Wald*: 4366: 4 Ex., Glashüttner Wald, bei Altglashütte, 49°46'13"N, 12°22'47"E, 749 m, Fichten, Tannen, 17.08.2019. 4365: 1 Ex., Wald Altherrgott, bei Mähring, 49°55'41"N, 12°29'37"E, 695 m, Fichten, Tannen, Buchen, 17.08.2019. 4364: 1 Ex., Klosterwald Archenoe/Hammerholz, bei Pfaffenreuth, 49°58'14"N, 12°18'38"E, 538 m, Fichten, Kiefern, Eichen, 17.08.2019.

*Fichtelgebirge*: 4367: 1 Ex., Bärenholz, bei Quellenreuth, 50°13'57"N, 11°59'03"E, 582 m, Fichten, 24.08.2019. 4298: 3 Ex., Rehauer Wald, bei Sophienreuth, 50°13'27"N, 12°05'28"E, 560 m, Fichten, 05.05.2018. 4207: 2 Ex., Dürschachtwald am Großen Hengstberg, bei Silberbach, 50°07'45"N, 12°10'56"E, 565 m, Fichten, Lärchen, 10.06.2017.

*Elstergebirge*: 4329: 1 Ex., Pechlohe, bei Raunergrund, 50°15'59"N, 12°18'25"E, 518 m, Fichten, 24.11.2018.

*Vogtland*: 4389: 2 Ex., Kämmerwald, bei Tanna, 50°28'13"N, 11°51'07"E, 584 m, Fichten, 28.09.2019. 4174: 1 Ex., Oschitzer Wald, bei Heinrichsruh, 50°32'23"N, 11°48'02"E, 552 m, Fichten, 19.11.2016. 4213: 2 Ex., Burgkwald, bei Burgk, 50°32'31"N, 11°42'51"E, 423 m, Fichten, Buchen, 29.07.2017. 4405: 1 Ex. Schleiz-Oberböhmischer Wald, bei Wüstendittersdorf, 50°34'02"N, 11°51'27"E, 474 m, Fichten, 13.10.2019. 4273: 6 Ex., Leitenholz, bei Rödersdorf, 50°38'01"N, 11°50'24"E, 447 m, Fichten, 04.11.2017. 4244: 2 Ex., Schwandhölzer, bei Dröswein, 50°35'16"N, 11°54'30"E, 479 m, Fichten, Kiefern, 23.09.2017. 4245: 3 Ex., ebenda, 50°35'12"N, 11°54'35"E, 490 m, Fichten, Kiefern, 23.09.2017. 4224: 4 Ex., Kettenwald, bei Dröswein, 50°36'00"N, 11°55'54"E, 438 m, Fichten, 20.08.2017. 4227: 4 Ex., Köthenwald, bei Grüngut, 50°36'34"N, 11°56'13"E, 435 m, Fichten, 25.08.2017. 4376: 1 Ex., Pahrenere Hölzer, bei Kleinwolschendorf, 50°38'44"N, 11°55'38"E, 405 m, Fichten, Eichen, 11.09.2019. 4246: 7 Ex., Mühltruffer Wald, bei Ranspach, 50°32'53"N, 11°57'50"E, 538 m, Fichten, Kiefern, 03.10.2017. 4247: 3 Ex., ebenda, 50°32'51"N, 11°57'42"E, 542 m, Fichten, 03.10.2017. 4253: 1 Ex., Hammerholz, bei Demeusel, 50°31'08"N, 11°58'35"E, 462 m, Fichten, Kiefern, 09.10.2017. 4254: 5 Ex., ebenda, 50°31'11"N, 11°58'40"E, 464 m, Fichten, Kiefern, 09.10.2017. 4383: 3 Ex., Eichigt, bei Rößnitz, 50°30'01"N, 12°01'20"E, 458 m, Fichten, Kiefern, 18.09.2019. 4384: 1 Ex., ebenda, 50°29'49"N, 12°01'27"E, 473 m, Fichten, Kiefern, 18.09.2019. 4382: 1 Ex., Syrau-Kauschwitzer Heide, bei Schneckenengrün, 50°31'14"N, 12°02'54"E, 527 m, Fichten, Kiefern, 18.09.2019. 4125: 2 Ex., Mehltheuerwald, bei Syrau, 50°32'32"N, 12°03'14"E, 512 m, Fichten, 13.08.2016. 4255: 9 Ex., Reiboldgrün, bei Leitlitz, 50°37'11"N, 11°59'17"E, 457 m, Fichten, Kiefern, 09.10.2017. 4168: 1 Ex., Reiboldgrün, bei Pöllwitz, 50°37'30"N, 12°00'24"E, 423 m, Buchen, Fichten, 31.10.2016. 4226: 5 Ex., Pöllwitzer Wald, bei Pöllwitz, 50°37'24"N, 12°03'03"E, 419 m, Fichten, Kiefern, 20.08.2017. 4162: 7 Ex., Pöllwitzer Wald, bei Welledorf, 50°37'21"N, 12°05'23"E, 450 m, Kiefern, Fichten, 20.10.2016. 4413: 1 Ex., Metschwald, bei Niederböhmersdorf, 50°39'21"N, 12°02'00"E, 428 m, Kiefern, Fichten, 23.10.2019. 4164: 1 Ex., Metschwald, bei Neuärgerniß, 50°39'27"N, 12°03'01"E, 409 m, Fichten, Eichen, 28.10.2016. 4170: 5 Ex., Niederböhmersdorfer Wald, bei Mehla, 50°40'43"N, 12°02'48"E, 410 m, Fichten, Kiefern, 04.11.2016. 4375: 1 Ex., Schömberger Wald, bei Steinsdorf, 50°45'06"N, 12°01'57"E, 374 m, Fichten, Kiefern, 11.09.2019. 4319: 1 Ex., Obere Harth, bei Langenwetzendorf, 50°40'35"N, 12°07'06"E, 386 m, Fichten, Erlen, 09.09.2018. 4372:

2 Ex., Bergaer Wald, bei Wernsdorf, 50°46'10"N, 12°08'02"E, 335 m, Fichten, Eichen, 04.09.2019. 4374: 2 Ex., Hofholz, bei Endschütz, 50°46'29"N, 12°08'03"E, 325 m, Kiefern, Buchen, 11.09.2019. 4153: 1 Ex., Greizer Wald, bei Kleinreinsdorf, 50°42'18"N, 12°12'51"E, 315 m, Fichten, Kiefern, 11.10.2016. 4048: 2 Ex., Greizer Wald, bei Waldhaus, 50°41'45"N, 12°15'42"E, 400 m, Fichten, Kiefern, 10.10.2015. 4049: 1 Ex., ebenda, 50°41'52"N, 12°14'55"E, 366 m, Fichten, Buchen, 22.10.2015. 4050: 8 Ex., ebenda, 50°41'55"N, 12°14'49"E, 354 m, Fichten, Kiefern, 22.10.2015. 4044: 3 Ex., Greizer Wald, bei Teichwolf Ramsdorf, 50°42'49"N, 12°15'05"E, 366 m, Fichten, Buchen, 06.10.2015. 4275: 7 Ex., Trünziger Wald, bei Wolf Ramsdorf, 50°45'29"N, 12°15'22"E, 355 m, Fichten, Kiefern, 09.11.2017. 4218: 4 Ex., Trünziger Wald, bei Walddorf, 50°44'12"N, 12°15'03"E, 348 m, Buchen, Kiefern, 07.08.2017. 4046: 12 Ex., Werdauer Wald, bei Reudnitz, 50°41'18"N, 12°17'17"E, 368 m, Kiefern, Fichten, 10.10.2015. 4021: 2 Ex., Schönfelser Wald, bei Ebersbrunn, 50°39'14"N, 12°24'38"E, 408 m, Fichten, Buchen, 05.09.2015. 4393: 2 Ex., Herlasgrüner Wald, bei Helmsgrün, 50°33'21"N, 12°13'27"E, 429 m, Fichten, Birken, Eichen, 03.10.2019. 4055: 2 Ex., Treuener Wald, bei Wolfspfütz, 50°33'36"N, 12°19'56"E, 454 m, Fichten, Buchen, 07.11.2015. 4122: 4 Ex., ebenda, 50°33'36"N, 12°20'01"E, 444 m, Fichten, Buchen, 13.08.2016. 4056: 2 Ex., Frohnholz, bei Altmannsgrün, 50°30'34"N, 12°18'54"E, 443 m, Fichten, 07.11.2015. 4057: 1 Ex., Mauerholz, bei Altmannsgrün, 50°30'14"N, 12°16'55"E, 460 m, Fichten, Lärchen, 07.11.2015. 4424: 2 Ex., Jägerswald, bei Tirpersdorf, 50°26'38"N, 12°15'27"E, 570 m, Fichten, 08.11.2019. 4330: 1 Ex., Görnitzholz, bei Raasdorf, 50°23'47"N, 12°12'47"E, 435 m, Fichten, Kiefern, 24.11.2018. 4304: 15 Ex., Tännicht, bei Leubetha, 50°20'50"N, 12°15'27"E, 470 m, Fichten, Kiefern, 19.05.2018. 4308: 2 Ex., Schirningwald, bei Süßebach, 50°21'06"N, 12°09'24"E, 580 m, Fichten, Kiefern, 09.06.2018. 4303: 11 Ex., Schirningwald, bei Tiefenbrunn, 50°20'01"N, 12°08'08"E, 612 m, Fichten, Kiefern, 19.05.2018. 4302: 7 Ex., Rehauer Wald, bei Ludwigsbrunn, 50°17'06"N, 12°06'13"E, 615 m, Fichten, Kiefern, 19.05.2018. 4371: 1 Ex., Löwitz, bei Rehau, 50°16'11"N, 12°02'50"E, 576 m, Fichten, Kiefern, Buchen, 24.08.2019.

*Mulde-Lösshügelland*: 1051: 1 Ex., Langer Busch, bei Wolperndorf, 50°54'53"N, 12°38'44"E, 265 m, Hainbuchen, Linden, 22.05.1991. 3910: 6 Ex., ebenda, 02.11.2014. 3912: 1 Ex., ebenda, 50°54'33"N, 12°38'28"E, 240 m, Birken, Linden, 02.11.2014. 1048: 3 Ex., ebenda, 50°54'15"N, 12°38'28"E, 225 m, Erlen, Linden, 11.05.1991. 3911: 4 Ex., ebenda, 02.11.2014.

4327: 2 Ex., Buchholz, bei Kaufungen, 50°54'14"N, 12°41'22"E, 252 m, Fichten, Lärchen, 09.11.2018. 4121: 3 Ex., Jahnshorn, bei Niederfrohna, 50°53'00"N, 12°43'06"E, 307 m, Eichen, Birken, 11.08.2016. 4151: 1 Ex., Tümmel, bei Pleiße, 50°49'35"N, 12°44'36"E, 418 m, Fichten, Lärchen, 07.10.2016. 4115: 1 Ex., Oberwald, bei Langenberg, 50°49'24"N, 12°43'17"E, 460 m, Fichten, Eichen, 18.07.2016. 3920: 1 Ex., Callenberger Kirchenholz, bei Callenberg, 50°50'44"N, 12°37'33"E, 288 m, Buchen, Eichen, 20.11.2014. 3922: 1 Ex., Callenberger Holz, bei Oberwinkel, 50°51'03"N, 12°37'21"E, 320 m, Buchen, Birken, 20.11.2014. 3923-3926: 12 Ex., Callenberger Holz, bei Naundorf, 50°51'29"N, 12°37'54"E, 328 m, Eichen, Buchen, 23.11.2014. 3927: 4 Ex., ebenda, 50°51'32"N, 12°37'45"E, 334 m, Buchen, Fichten, 23.11.2014. 4117: 1 Ex., Waldenburger Stadtwald, bei Langenchursdorf, 50°52'22"N, 12°37'57"E, 280 m, Fichten, Eichen, 07.08.2016. 4118: 3 Ex., ebenda, 50°52'25"N, 12°38'06"E, 302 m, Eichen, Kiefern, 07.08.2016. 4358: 14 Ex., Gersdorfer Wald, bei Remse, 50°51'22"N, 12°35'20"E, 235 m, Fichten, 21.06.2019. 3908,3918,3919: 8 Ex., Klosterholz, bei Weidensdorf, 50°51'45"N, 12°32'17"E, 275 m, Erlen, Eichen, 31.10. und 11.11.2014. 3909: 1 Ex., ebenda, 50°51'43"N, 12°32'25"E, 282 m, Buchen, 31.10.2014. 1070: 1 Ex., ebenda, 50°51'39"N, 12°32'42"E, 292 m, Birken, Eichen, 19.06.1991. 3913: 1 Ex., ebenda, 03.11.2014. 1071: 1 Ex., Klosterholz, bei Kleinchursdorf, 50°51'31"N, 12°33'07"E, 283 m, Erlen, Eichen, 19.06.1991. 4397: 5 Ex., Eichlaide, bei Dürrenuhlsdorf, 50°53'14"N, 12°36'56"E, 275 m, Fichten, 06.10.2019. 4398: 3 Ex., ebenda, 50°53'12"N, 12°37'02"E, 281 m, Buchen, 06.10.2019.

*Erzgebirgsbecken:* 4007: 2 Ex., Harthwald, bei Mosel, 50°46'48"N, 12°26'47"E, 296 m, Eichen, Lärchen, 05.08.2015. 4014: 3 Ex., Schäbigtwald, bei Kalthausen, 50°47'47"N, 12°27'36"E, 297 m, Kiefern, Eichen, 23.08.2015. 4149: 1 Ex., Rabensteiner Wald, bei Grüna, 50°48'58"N, 12°45'55"E, 418 m, Fichten, Buchen, 04.10.2016. 4150: 3 Ex., ebenda, 50°49'01"N, 12°45'43"E, 432 m, Fichten, 07.10.2016. 4004: 3 Ex., Buchwald, bei Rödlitz, 50°43'23"N, 12°40'29"E, 453 m, Fichten, Kiefern, Buchen, 31.07.2015. 3998: 2 Ex., Neudörfler Wald, bei Neuschönburg, 50°42'42"N, 12°39'33"E, 433 m, Fichten, Kiefern, 14.07.2015. 4041: 1 Ex., Lichtensteiner Stadtwald, bei Lichtenstein/ Sa., 50°45'41"N, 12°39'09"E, 338 m, Erlen, Birken, 30.09.2015. 4030: 1 Ex., Burgwald, bei Heinrichsort, 50°44'02"N, 12°37'42"E, 380 m, Fichten, Lärchen, 21.09.2015. 4001: 2 Ex., Zschockener Holz, bei Zschocken, 50°39'38"N, 12°38'08"E, 396 m, Fichten, Buchen, 28.07.2015. 4107: 7 Ex., Vielauer Wald, bei Vielau, 50°41'04"N, 12°31'36"E, 329 m, Eichen,

Birken, 27.06.2016. 4152: 1 Ex., Werdauer Wald, bei Langenbernsdorf, 50°44'02"N, 12°18'43"E, 331 m, Fichten, Buchen, 09.10.2016. 4154: 2 Ex., Kleiner Wald, bei Langenbernsdorf, 50°43'58"N, 12°16'11"E, 346 m, Buchen, Kiefern, 11.10.2016.

*Westerzgebirge:* 3970: 1 Ex., Unterer Wiesenburger Wald, bei Hartmannsdorf b. Kirchberg, 50°35'40"N, 12°33'38"E, 483 m, Fichten, Eichen, 31.05.2015. 3971: 9 Ex., Unterer Wiesenburger Wald, bei Saupersdorf, 50°36'16"N, 12°33'25"E, 441 m, Birken, Eichen, 31.05.2015. 4113: 1 Ex., Kirmesmoos, bei Jägerhaus, 50°31'00"N, 12°42'42"E, 755 m, Fichten, Buchen, 16.07.2016. 4112: 3 Ex., Friedrichsheide, bei Erlabrunn, 50°28'54"N, 12°42'29"E, 725 m, Fichten, Buchen, 16.07.2016. 4111: 1 Ex., Wald am Auersberg, bei Sauschwemme, 50°26'23"N, 12°40'15"E, 842 m, Fichten, 16.07.2016. 4110: 3 Ex., Wintergrün, bei Carlsfeld, 50°26'32"N, 12°35'15"E, 916 m, Fichten, 16.07.2016. 4102: 1 Ex., Pyrawald, bei Sachsengrund, 50°25'01"N, 12°32'27"E, 830 m, Fichten, 11.06.2016. 4103: 1 Ex., ebenda, 50°24'55"N, 12°32'27"E, 863 m, Fichten, Buchen, 11.06.2016. 4101: 5 Ex., Riedert, bei Wilzschhaus, 50°28'02"N, 12°31'40"E, 630 m, Tannen, Fichten, 11.06.2016. 4098: 3 Ex., Grüner Wald, bei Hammerbrücke, 50°27'14"N, 12°24'17"E, 706 m, Buchen, Fichten, 28.05.2016. 4097: 3 Ex., Heroldswald, bei Muldenberg, 50°25'41"N, 12°22'29"E, 730 m, Fichten, 28.05.2016.

*Mittlerzgebirge:* 4040: 5 Ex., Neudörfler Wald, bei Ortmannsdorf, 50°41'09"N, 12°37'46"E, 412 m, Fichten, Birken, 30.09.2015. 4434: 1 Ex., Heiliger Wald, bei Mitteldorf, 50°41'21"N, 12°47'17"E, 505 m, Kiefern, Fichten, Birken, 24.11.2019. 4106: 1 Ex., Hauwald, bei Jahnsdorf/ Erzgeb., 50°43'24"N, 12°50'29"E, 510 m, Fichten, Buchen, 20.06.2016. 4429: 2 Ex., Lohwald, bei Gornsdorf, 50°41'28"N, 12°52'48"E, 524 m, Fichten, 16.11.2019. 4407: 2 Ex., Kemtauer Wald, bei Kemtau, 50°44'17"N, 12°58'34"E, 402 m, Fichten, 17.10.2019. 4408: 3 Ex., Einsiedler Wald, bei Altenhain, 50°46'46"N, 12°59'20"E, 450 m, Fichten, 17.10.2019. 4210: 2 Ex., Struth, bei Erdmannsdorf, 50°49'52"N, 13°04'25"E, 307 m, Fichten, Kiefern, 08.07.2017. 4430: 1 Ex., Heinzewald, bei Heinzebank, 50°41'15"N, 13°08'13"E, 595 m, Fichten, Buchen, 16.11.2019. 4418: 1 Ex., Geyerscher Wald, bei Jahnsbach, 50°39'00"N, 12°55'16"E, 665 m, Fichten, 04.11.2019. 4419: 7 Ex., ebenda, 50°38'55"N, 12°54'56"E, 642 m, Fichten, Buchen, 04.11.2019. 3989: 1 Ex., Geyerscher Wald, bei Dorfchemnitz, 50°39'08"N, 12°51'10"E, 570 m, Fichten, 27.06.2015. 3876: 1 Ex., Hartensteiner Wald, bei Raum, 50°39'02"N, 12°42'10"E, 506 m, Fichten, Buchen, 27.09.2014.

*Osterzgebirge:* 4400: 2 Ex., Viehwegbusch, bei Bockendorf, 50°55'03"N, 13°08'44"E, 413 m, Fichten,



Kiefern, Birken, 11.10.2019. 4347: 4 Ex., Tharandter Wald, bei Grund, 50°59'49"N, 13°28'47"E, 326 m, Kiefern, Buchen, 27.04.2019. 4344: 2 Ex., Tharandter Wald, bei Grillenburg, 50°57'36"N, 13°30'56"E, 349 m, Fichten, Eichen, 27.04.2019. 4345: 1 Ex., Tharandter Wald, bei Kurort Hartha, 50°58'03"N, 13°31'24"E, 340 m, Fichten, 27.04.2019. 4426: 7 Ex., Dipoldiswalder Heide, bei Karsdorf, 50°55'38"N, 13°41'29"E, 362 m, Fichten, 10.11.2019. 4427: 5 Ex., ebenda, 50°55'39"N, 13°41'14"E, 374 m, Kiefern, Fichten, 10.11.2019. 4350: 1 Ex., Vorderer Grünwald, bei Rehefeld-Zaunhaus, 50°44'59"N, 13°42'15"E, 812 m, Fichten, Buchen, 11.05.2019. 4351: 4 Ex., Töpferwald, bei Neuhermsdorf, 50°44'17"N, 13°38'13"E, 767 m, Fichten, Buchen, 11.05.2019.

Sächsische Schweiz: 3239: 1 Ex., Mittlerer Beutwald, bei Rosenthal, 50°50'24"N, 14°01'05"E, 442 m, Fichten, Buchen, 02.10.2011.

## DISKUSSION

### Areal, Arealgrenze, Feuersteinlinie und Bodenausgangsgesteine

Unser Beitrag belegt durch einwandfreie faunistische Unterlagen für 126 Fundorte, dass *D. illyrica* im untersuchten Gebiet weiter verbreitet ist, als bisher bekannt war. Unsere Funde umreißen den nordwestlichen Teil des Areals der Art, erhellen ihn aufgrund der Methodik aber nicht flächendeckend. Der Kartierungsmaßstab und die Trefferquote unserer Untersuchungen erlauben dennoch anzunehmen, dass diese Art ein kontinuierliches Areal auf dem östlichen Teil der Mitteleuropäischen Mittelgebirgsschwelle besiedelt. Dieses Areal liegt in jenem Gebiet, das vor Beginn der historischen Zeit von natürlichen Buchenwäldern der montanen Höhenstufen mit Tanne und Fichte eingenommen wurde (Firbas 1949, Walter & Straka 1970, Breckle & Agachanjanz 1994).

Da die ermittelte Nordgrenze des Areals von *D. illyrica* annähernd der Feuersteinlinie entspricht, ist diese Regenwurmart in ihrer Verbreitung auf ein geographisches Gebiet beschränkt, das seit dem Prälsterglazial eine ortsbürtige Kaltzeit-Verwitterungsdecke trägt (Büdel 1981), auf der sich über sehr lange Zeit relativ konti-

nuierlich Boden entwickelte. Die epigäische *D. illyrica* bevorzugt im Bodenprofil den Grenzbereich von Auflagehumus und schwach humosem Mineralhorizont, ist aber offensichtlich von der über lange Zeit entstandenen lithogenen mineralischen Grundausrüstung des Bodens abhängig. Denn diese Art wurde in jenen Gebieten nicht vorgefunden, wo der elstereiszeitliche Gletscher die Verwitterungs- und Bodendecke ausgeräumt hatte oder diese als kryoturbat bis gravitativ zu Tal gleitendes periglaziales Material beim Eisrückschmelzen vollständig fluvial abgeführt wurde. Die von *D. illyrica* besiedelten Böden besitzen offenbar hohe Anteile von Kaltzeit-Verwitterungsprodukten, die im Zuge periglazialer Prozesse wie Kryoturbation und Kryotranslokation (Altermann *et al.* 2008) als Feinboden oder Bodenskelett in die Bodendecke eingemischt wurden. Zwischen zwei Eiszungen des Elster-1-Gletschers blieben die Verwitterungs- und Bodendecken offensichtlich weitgehend erhalten, wofür die *illyrica*-Vorkommen im Lohwald und östlichen Hauwald (4429, 4106) sprechen.

Das Areal von *D. illyrica* endet an seiner Nordwestgrenze mit der fichtelgebirgisch-erzgebirgischen Vorherrschaft (BGR 2016) der sauren Magmatite und Metamorphite als siliziumreiche Bodenausgangsgesteine. Dieses und die für regionale Stenözie sprechende Häufung von Funden am nordwestlichen Rand des Art-Areals, zwischen Oberer Saale und Weißer Elster, deuten wir als Zeichen einer engen Beziehung dieser Regenwurmart zu Verwitterungsprodukten aus diesen Gesteinen. Dem entspricht auch das Verschwinden der Art beim Übergang zur Ziegenrücker Mulde, wo höhere Anteile basischer Gesteine verwitterten. Die Verteilung der Art im untersuchten Gebiet belegt auch vereinzelte Vorkommen in Böden über angrenzenden Tongesteinen und Sandsteinen. Das gründet sich wohl auf die Tatsache, dass die Böden in den seltensten Fällen unmittelbar die Verwitterungsprodukte der am Standort selbst im Untergrund anstehenden Gesteine sind (Völkel *et al.* 2002). Die Böden des untersuchten Gebiets entwickelten sich in lithogenen Deckschichtprofilen, die aus jenen Gesteinen und/oder Böden entstanden, die im peri-

glazialen Milieu der Standort-Umgebung umgebildet wurden. Die Schichten (Lagen) dieser Profile, so auch die allgemein oberflächenbildende Hauptlage, sind das Ergebnis von Turbationen und lateralen Umlagerungen, insbesondere von solifluidalem Ab- und Auftrag, und bestehen aus einem Lokalanteil, dem Verwitterten des liegenden Gesteins, und (z.B. äolischen) Fremddanteilen (Altermann 1993). Insofern variiert der unzweifelhaft bestehende Zusammenhang von stofflicher Zusammensetzung der Böden und dem liegendem Gestein des Standorts und stellt somit einen Valenzgradienten für *D. illyrica* dar.

Die am Talhang der Zwickauer Mulde nördlich der Feuersteinlinie, also im Randbereich maximaler Elstereisverbreitung, nachgewiesenen Vorkommen von *D. illyrica* (Schäbigtwald, Harth bei Mosel, Klosterholz, Langer Busch, Buchholz bei Kaufungen) deuten wir als Zeichen von Ablagerungen, die im Elster-2-Stadium erfolgten, aus der präelsterglazial begonnenen westerzgebirgischen Kaltzeit-Verwitterungsdecke stammen (Alexowsky *et al.* 2007, Wolf & Alexowsky 2008) und an der Bildung rezenten Bodens teilnahmen. Wahrscheinlich hat dieses Material (gQE2) trotz Umlagerung die für *D. illyrica* wichtigen Eigenschaften der mineralischen Grundausrüstung bewahrt. Auch diese Beobachtung spricht für die Bindung der Regenwurmart an Faktoren aus der Verwitterungsdecke, die sich seit dem Praeelsterglazial entwickelte.

Mit dem Verlust der präelsterglazialen Verwitterungsdecke durch Vollabtrag nördlich der Feuersteinlinie im Verlaufe des Elsterglazials fiel offenbar die Grundlage einer Bodenentwicklung weg, die nicht nur für *D. illyrica*, sondern für viele Regenwurmartensarten lebensnotwendig ist. Das halten wir für die Ursache der von Michaelsen (1902) und Julin (1950) vorgestellten nördlichen Verbreitungsgrenze der endemischen Lumbriciden-Arten in der Holarktischen Region.

### **Parthenogenese, Selektionstypen, Metapopulationen**

Die von uns gefundenen sichtlich erwachsenen Individuen von *D. illyrica*, die im Hinblick auf die

schmalere Drüsenhöfe ihrer männlichen Poren und auf die Pubertätswälle als äußerlich nicht voll ausgeprägte erscheinen, einen nicht sattelförmigen Gürtel und in einigen Fällen einen verkürzten Gürtel besitzen, stellen wir zur parthenogenetischen Form der Art. Den parthenogenetischen Regenwürmern fehlen bekanntlich in verschiedenen Graden einige sekundäre sexuelle Organe und morphologische Merkmale (Sims & Gerard 1985, Edwards & Bohlen 1996). Als Indikatoren für Parthenogenese betrachten wir das Fehlen der Pubertätswälle (Gates 1972, Hartenstein *et al.* 1980, Christian & Zicsi 1999) und der drüsigen Hautverdickungen im männlichen Porushof, dessen dann unscheinbares Bild zumindest auf Retention der Vas deferens in einem jugendlichen Zustand und damit auf männliche Sterilität hindeutet. Der sattelförmige Gürtel kennzeichnet die sexuelle, Spermatophoren bildende Form der Art (Zicsi 1965).

Den am untersuchten Arealrand der *D. illyrica* angedeuteten Kranz aus Fundpunkten wahrscheinlich parthenogenetischer Individuen halten wir für das Zeichen geographischer Parthenogenese (Vandel 1928). In solchem Falle besetzen die sich geschlechtlich fortpflanzenden Individuen den zentralen Bereich des Areals der Art, während die parthenogenetischen überwiegend am Arealrand vorkommen. Diese geographische Verteilung der beiden Fortpflanzungsformen wurde z.B. auch bei Diplopoden und Schaben festgestellt (Enghoff 1994, dort Fig. 2, bzw. Knebelsberger & Bohn 2003, dort Fig. 6).

Parthenogenetische Individuen sind besser an unvorteilhafte Umweltbedingungen angepasst (Vandel 1940), z.B. an die kurzlebigen, an der Bodenoberfläche fleckig verteilten Ressourcen (Streu usw.), die sie mittels hoher Ansiedlungsfähigkeit und raschem Populationswachstum bei r-Selektion erfolgreich ausnützen. Demgegenüber herrscht im mineralischen Oberboden größere räumliche Kontinuität und zeitliche Stabilität, charakteristisch für ein Habitat, in dem K-Selektion zu erwarten ist (Jaenike & Selander 1979). Bei *D. illyrica* fallen Zeichen beider Selektionstypen auf: Die Art wird der epigäischen

Lebensform zugeordnet (Pižl 2002a); wir fanden am Arealrand Habitate, in denen wie in der Periode aktiver Vermehrung (Edwards & Lofty 1977) die immaturen die adulten Individuen anzahlmäßig stark überwogen (z.B. 3910, 4303), so auf wahrscheinliche r-Selektion hindeutend.

In suboptimalen Habitaten, vor allem am Arealrand, stellten wir überwiegend der parthenogenetischen Form zugeordnete Individuen fest. Eine ebensolche Relation in der Gesamtmenge der gesammelten erwachsenen Individuen erklärt sich aus der Nähe des untersuchten Gebietes zum Arealrand. Andererseits ermittelten wir im Arealinneren Fundpunkte von vollausgeprägten Individuen der Art. Bösenner (1964) traf *D. illyrica* in der Nähe des Arealrands (Tharandter Wald) „nie im Mineralboden“, nur in der Humusaufgabe der Waldbestände an. Im arealweiten Blickwinkel von Zicsi (1965) lebt die Art „in der Laubstreu und in der obersten Bodenschicht“. Unseren Beobachtungen zufolge tritt sie im Horizontbereich von Auflagehumus und oberflächennächstem Mineralboden auf. Das deutet eingedenk der oben angenommenen geographischen Parthenogenese darauf hin, dass *D. illyrica* möglicherweise Metapopulationen bildet, die aus parthenogenetischen und geschlechtlichen Unterpopulationen bestehen, wobei die parthenogenetischen besonders die Streu und den Auflagehumus nutzen, während die geschlechtlichen den obersten humosen Mineralboden bevorzugen. Einer Hypothese von Haag & Ebert (2004) und unseren Beobachtungen zufolge erwarten wir derartige Metapopulationen in suboptimalen Habitaten und am Arealrand, wo weniger günstige Bedingungen herrschen und die Art vermutlich im häufigen Wechsel von lokaler Auslöschung und Wiederbesiedlung steht. Dabei sind die parthenogenetischen Unterpopulationen aufgrund ihrer körperlichen Verfassung in der Lage, durch ihre größere Dynamik (r-Strategie) den Bestand dieser Art zu erhalten.

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# Zooplankton diversity of a subtropical reservoir of Meghalaya, northeast India with remarks on spatial and temporal variations

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**Abstract.** Nongmahir reservoir of Meghalaya state of northeast India (NEI), sampled at the littoral and limnetic regions, revealed fairly biodiverse zooplankton of total 56 species with peak consortium (52 species) in January collection from the littoral region. The richness indicated spatial monthly variations and heterogeneity at the two regions mainly influenced by Rotifera. The ‘soft and de-mineralized waters’ resulted in low zooplankton abundance. Copepoda > Rotifera with Cyclopidae > Brachionidae influenced zooplankton, and *Mesocyclops leuckarti* > *Keratella cochlearis* > *Ascomorpha ovalis* > *Microcyclops hyalinus* are notable species at the littoral region. The limnetic region recorded Rotifera dominance, and importance of Brachionidae > Cyclopidae and *K. cochlearis* > *Conochilus unicornis* > *M. leuckarti* > *A. ovalis* > *Asplanchna priodonta* > *Polyarthra vulgaris*. Zooplankton recorded moderate species diversity and notable differences of evenness and dominance. The spatial monthly differences of richness, abundance and diversity indices of zooplankton, and importance of notable taxa are hypothesised to habitat heterogeneity of the two regions. Our results also indicated limited and differential influence of individual abiotic factors on zooplankton taxa, while the canonical correspondence analysis registered high cumulative influence of 10 abiotic factors on the littoral (80.62%) and limnetic (74.79%) assemblages along axis 1 and 2. This study highlighted distinct temporal variations of different diversity parameters than our preliminary survey of June 1995–May 1996.

**Keywords.** Composition, richness, abundance, diversity indices, demineralized, soft-water.

## INTRODUCTION

Zooplankton, an integral part of aquatic food-webs and important fish-food organisms, has been studied from diverse aquatic biotopes since inception of the Indian limnology but received relatively less attention from lakes and reservoirs (Jana 1998). This generalization holds valid the current status of lacustrine limnology of India and that of north India in particular because of sizeable number of ‘routine’ ecology reports with incomplete species lists, unidentified species and inadequate data-analysis (Sharma & Pachuau 2013). However, certain meaningful studies on zooplankton assemblages from the sub-tropical regions of India are those of Sharma and Pant (1984, 1985), Raina & Vass (1993), Mishra *et al.* (2010), Ahangar *et al.* (2012), Jindal & Thakur (2013), Slathia & Dutta (2013), Thakur *et al.*

(2013), Malik & Panwar (2016), Sharma & Kumari (2018) and Singh & Sharma (2020). The related works of Sharma & Hussain (2001), Sharma (2011a, 2011b), Sharma & Sharma (2008, 2011, 2012), Sharma & Hatimuria (2017) and Sharma & Noroh (2020) dealt with zooplankton of the floodplain lakes of NEI. However, the studies on zooplankton diversity from reservoirs of NEI are limited till date to ‘ad-hoc’ reports from Gumti reservoir of Tripura (Bhattacharya & Saha 1986, 1990), and the preliminary surveys of the subtropical reservoirs from Meghalaya (Sharma 1995, Sharma and Lyngskor 2003, Sharma & Lyngdoh 2004) and Mizoram (Sharma & Pachuau 2013).

The present study, a follow-up of our limited survey of June 1995 – May 1996 (Sharma and Lyngskor 2003), undertaken to provide detailed

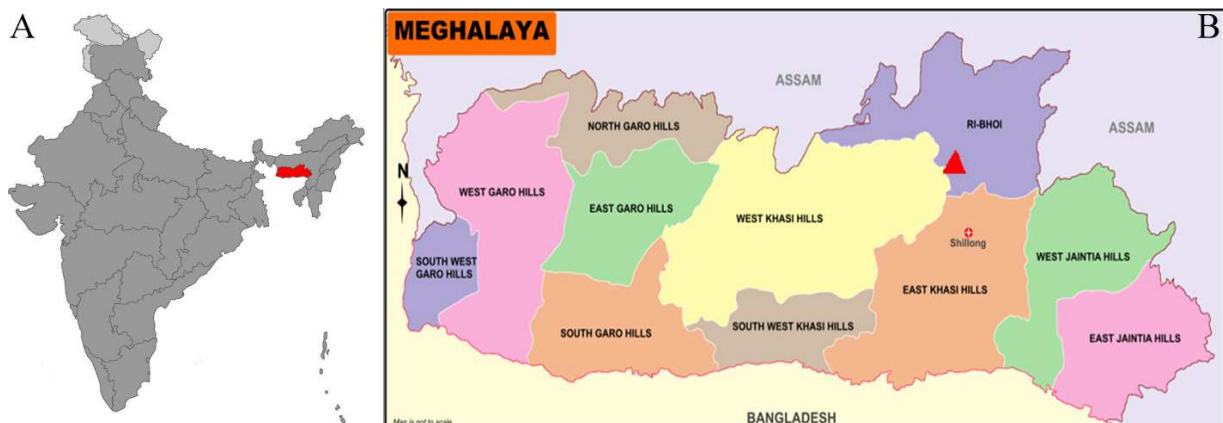
information on zooplankton diversity of a subtropical reservoir of Meghalaya, assumes limnological interest in light of the stated lacunae. It is based on analyses of monthly littoral and limnetic net plankton collections with reference to species composition, richness, community similarities, abundance, species diversity, dominance and evenness, and individual and cumulative influence of abiotic factors on zooplankton assemblages. The results are compared with the related studies from the sub-tropical lakes of the Himalayan and sub-Himalayan regions of north India, the floodplain lakes and the sub-tropical environs of NEI, lacustrine ecosystems elsewhere from India and certain reports from adjacent countries of the Indian sub-region. We attempt to highlight spatial variations of different aspects of diversity based on our studies at the littoral and the limnetic regions, and temporal variations in comparison with the earlier survey of June 1995 – May 1996.

## MATERIALS AND METHODS

The study is based on limnological survey (January – December, 2015) of Nongmahir reservoir (25.7876°N; 91.8251°E; area: 70 ha; maximum depth: 25 m) located in Ri-Bhoi district (Fig. 1A–B), at a distance of about 45 km. from Shillong city – the capital of Meghalaya state of NEI. Nongmahir was commissioned in 1979 to serve as a pick up reservoir (Stage III) of the Umiyam-Umtru hydroelectric project. This reservoir lacks any a

quatic vegetation. *Catla catla*, *Cirrhinus mrigala*, *Cyprinus carpio*, *Clarias batrachus*, *Dania rerio*, *D. acquipinnatus*, *D. dangila*, *Heteropneustes fossilis*, *Labeo rohita*, *Neolissocheilus hexagonolepis*, *Puntius sophore* and *Tor putitora* are the fish species known to inhabit this reservoir.

Water samples were collected monthly from the littoral and limnetic regions. Water temperature was recorded with a centigrade thermometer, transparency with Secchi disc, pH and specific conductivity with the field probes, dissolved oxygen by the modified Winkler's method, and other abiotic factors: total alkalinity, total hardness, calcium, magnesium, chloride, dissolved organic matter, phosphate, nitrate and sulphate were analyzed following APHA (1992). Rainfall data was obtained from the local meteorological station. The qualitative net plankton samples collected from the two regions by towing nylobolt plankton net (mesh size: 40 µm) were preserved in 5% formalin. All the collections were screened with a Wild Stereoscopic binocular microscope, zooplankton were isolated and mounted in polyvinyl alcohol–lactophenol mixture, and were observed with Leica stereoscopic microscope (DM 1000). The species were identified following Michael & Sharma (1988), Sharma (1983, 1998), Sharma and Sharma (1999a, 1999b, 2008). The community similarities were calculated vide Sørensen's index and the hierarchical cluster analysis using SPSS (version 20).



**Figure 1.** A = map of India showing Meghalaya state (red color), B = District map of Meghalaya showing Nongmahir reservoir (red triangle) in Ri-Bhoi district.

The monthly quantitative net plankton samples were obtained by filtering 25 L of water each from the littoral and limnetic regions through nylobolt plankton net and were preserved in 5% formalin. Quantitative enumeration of zooplankton assemblages was done with a Sedgewick-Rafter counting cell and abundance was expressed as ind. l<sup>-1</sup> as well as ranges and means  $\pm$  S.D. Species diversity (Shannon-Weiner index), dominance (Berger-Parker index) and evenness ( $E_1$  index) were calculated following Ludwig & Reynolds (1988) and Magurran (1988). The significance of variations of the different abiotic and biotic factors between the sampled regions and months was ascertained by two-way ANOVA. Pearson's correlation coefficients were calculated between abiotic and biotic parameters for the littoral and limnetic regions ( $r_1$  and  $r_2$ , respectively), p values (2-tailed) were calculated *vide* <http://vassarstats.net/tabs.html> and their significance were ascertained after applying Bonferroni corrections. The canonical correspondence analysis (CCA) was done using XLSTAT (2015) to observe cumulative influence of ten abiotic parameters (for limitations of the sampled months) namely water temperature, rainfall, transparency, pH, specific conductivity, dissolved oxygen, free carbon dioxide, total alkalinity, total hardness and chloride on zooplankton and important taxa. The study period is divided into winter (December-February), spring (March), pre-monsoon (April-June), monsoon (July-October) and autumn (November) seasons for better explanation of our results; NEI experiences extended rainfall from pre-monsoon to monsoon seasons, and pre-monsoon equates with summer season elsewhere in India.

## RESULTS

The variations of abiotic and biotic factors at the littoral and limnetic regions noted *vide* this study as well as June 1995 – May 1996 survey are presented in Tables 1–2.

We recorded total 56 species of zooplankton with 56 and 41 species recorded from the two regions, respectively of Nongmahir reservoir;

Rotifera, Cladocera, Rhizopoda, Copepoda and Ostracoda indicated 32, 10, 9, 4 and 1 species, respectively (Table 2). The monthly zooplankton richness ranged between 27–52 and 19–32 species and registered 57.6–85.7% and 51.1–88.9% community similarities, and Rotifera richness varied between 13–31 and 10–17 species, at the two regions, respectively. The hierarchical cluster analysis (Figs. 2–3) exhibited differences in the cluster groupings at the littoral and limnetic regions. The monthly variations in abundance of zooplankton, important groups and species are indicated in Table 2 as well as June 1995–May 1996 survey, and the details are presented in Appendices I–II. Zooplankton abundance ranged between 131–279 and 96–425 ind.l<sup>-1</sup> and comprised between 23.3 $\pm$ 10.0, 32.2 $\pm$ 10.6% of net plankton abundance at the littoral and limnetic regions respectively (Table 2). Rotifera (27–158, 67–315 ind.l<sup>-1</sup>), Copepoda (30–97, 8–122 ind.l<sup>-1</sup>), and Cladocera (29–48, 7–29 ind.l<sup>-1</sup>) comprised between 37.3 $\pm$ 17.1, 69.7 $\pm$ 14.0%; 40.5 $\pm$ 18.2, 19.2 $\pm$ 11.7%; and 19.0 $\pm$ 5.3, 7.9 $\pm$ 3.8% of zooplankton abundance at the two regions respectively (Table 2). Rhizopoda and Ostracoda recorded low densities. Brachionidae (25 $\pm$ 33, 48 $\pm$ 57 ind.l<sup>-1</sup>) and Cyclopidae (60 $\pm$ 42, 31 $\pm$ 27 ind.l<sup>-1</sup>) are notable families, while Bosminidae (13 $\pm$ 7, 9 $\pm$ 5 ind.l<sup>-1</sup>) and Chydoridae (13 $\pm$ 4, 4 $\pm$ 3 ind.l<sup>-1</sup>) indicated limited importance; the species *Mesocyclops leuckarti* (50 $\pm$ 38, 31 $\pm$ 27 ind.l<sup>-1</sup>), *Keratella cochlearis* (20 $\pm$ 34, 47 $\pm$ 57 ind.l<sup>-1</sup>), *Ascomorpha ovalis* (19 $\pm$ 21, 27 $\pm$ 17 ind.l<sup>-1</sup>) indicated importance at the two regions, respectively. In addition, *Conochilus unicornis* (36 $\pm$ 49 ind.l<sup>-1</sup>), *Asplanchna priodonta* (17 $\pm$ 17 ind.l<sup>-1</sup>) and *Polyarthra vulgaris* (10 $\pm$ 6 ind.l<sup>-1</sup>) deserved attention in the limnetic collections, and *Microcyclops hyalinus* (10 $\pm$ 4 ind.l<sup>-1</sup>) is notable at the littoral region. The significance of various abiotic and biotic factors (*vide* ANOVA) between the littoral and limnetic regions and months are indicated in Table 3. Zooplankton species diversity (Fig. 4) ranged between 2.047–3.481 and 1.607–2.847 (2.217  $\pm$  0.327), and evenness and dominance between 0.596 – 0.881 and 0.520 – 0.838, and 0.146 – 0.502 and 0.185 – 0.459, at the two regions, respectively. Rotifera richness is



**Table 1.** Variations of abiotic factors

Stations→ Factors ↓	Littoral region		Limnetic region		June 1995–May 96
	Range	Mean ± S.D	Range	Mean ± S.D	Mean ± S.D
Water temperature °C	16.0–24.0	20.7 ± 2.7	16.5–24.5	20.8 ± 2.6	21.1±4.4
Rainfall mm	1.4–803.2	230.2 ± 227.8	1.4v803.2	230.2 ± 227.8	175.2 ± 206.8
Transparency cm	75–110	92.5 ± 10.1	80–120	100.8 ± 12.4	1.9 ± 0.4
pH	6.7–7.2	6.95 ± 0.16	6.8–7.2	6.95 ± 0.13	8.1 ± 0.6
Specific conductivity µS/cm <sup>-1</sup>	40.2–57.8	50.3 ± 5.3	38.8–58.0	50.0 ± 6.3	35.5 ± 7.7
Dissolved oxygen mg l <sup>-1</sup>	7.0–9.6	8.2 ± 0.7	7.4–9.0	8.3 ± 0.6	6.5 ± 0.6
Free Carbon dioxide mg l <sup>-1</sup>	9.0–14.0	11.3 ± 1.5	6.0–8.0	7.1 ± 0.9	2.8 ± 0.9
Total Alkalinity mg l <sup>-1</sup>	24.0–48.0	33.0 ± 6.8	28.0–46.8	36.3 ± 5.7	27.5 ± 5.7
Total Hardness mg l <sup>-1</sup>	16.8–32.0	23.0 ± 4.8	18.6–38.8	25.6 ± 5.8	21.5±5.7
Calcium mg l <sup>-1</sup>	9.8–19.2	13.9 ± 3.4	10.0–18.7	13.7 ± 2.6	10.6 ± 3.3
Magnesium mg l <sup>-1</sup>	1.2–4.2	2.2 ± 0.8	1.0–5.0	2.2 ± 1.1	2.6 ± 0.9
Chloride mg l <sup>-1</sup>	12.0–18.0	14.5 ± 2.1	10.2–17.8	13.7 ± 2.0	6.7 ± 1.2
Phosphate mg l <sup>-1</sup>	0.090–0.208	0.151 ± 0.041	0.102–0.234	0.160 ± 0.046	0.13 ± 0.06
Sulphate mg l <sup>-1</sup>	0.159–2.020	1.022 ± 0.664	0.259–2.004	0.939 ± 0.558	5.5 ± 2.2
Nitrate mg/l	0.062–0.108	0.090 ± 0.016	0.052–0.110	0.086 ± 0.016	1.3±1.1
Dissolved organic matter mg l <sup>-1</sup>	2.2–4.8	3.1 ± 0.7	1.6–3.4	2.1 ± 0.6	-

**Table 2.** Qualitative and quantitative variations of zooplankton

RICHNESS					
	Littoral region		Limnetic region		June 1995–May 1996
	Zooplankton Total	56 species		41 species	
Monthly	27–52	35 ± 6	19–32	22 ± 3	10–22 15 ± 3
Community similarity	57.6 – 85.7%		51.1– 88.9%		
Rotifera Total	32 species		23 species		14 species
Monthly	13–31	18 ± 4	10–17	12 ± 2	-
ABUNDANCE					
Net Plankton ind.l <sup>-1</sup>	436–1736	1053 ± 421	363–1346	747 ± 325	80–312 164 ± 77
Zooplankton ind.l <sup>-1</sup>	131–279	200 ± 42	96–425	218 ± 103	17–109 55 ± 26
Percentage	10.4–35.2	23.3 ± 10.0	19.9–55.1	30.2 ± 10.6	43.6 ± 26.4
Species Diversity	2.047–3.481	2.584± 0.378	1.607–2.847	2.217± 0.327	1.891–2.840 2.254 ± 0.289
Dominance	0.146–0.502	0.329± 0.126	0.185–0.459	0.351 ± 0.112	0.133–0.392 0.296 ± 0.098
Evenness	0.596–0.881	0.727± 0.086	0.520–0.838	0.717 ± 0.096	0.761–0.988 0.838 ± 0.090
Important Groups					
Rotifera ind.l <sup>-1</sup>	27–158	78 ± 43	67–315	151 ± 80	5–13 9±3
Percentage	14.9–66.1	37.3 ± 17.1	32.4–86.5	69.7 ± 14.0	
Copepoda ind.l <sup>-1</sup>	30–97	82±46	8–122	48±34	6–73 31±26
Percentage	13.8–70.6	40.5 ± 18.2	4.5–43.6	19.2±11.7	
Cladocera ind.l <sup>-1</sup>	29–48	36 ± 6	7–29	15 ± 6	3–34 14± 9
Percentage	11.1–31.2	19.0 ± 5.3	3.0–17.1	7.9±3.8	
Important Families (ind.l <sup>-1</sup> )					
Brachinoidae	3–100	25 ± 33	6–211	48 ± 57	-
Cyclopidae	15–162	60 ± 42	5–90	31 ± 27	-
Bosminidae	5–22	13 ± 7	4–21	9 ± 5	-
Chydoridae	6–20	13 ± 4	2–11	4 ± 3	-
Important Species (ind.l <sup>-1</sup> )					
<i>Mesocyclops leuckarti</i>	10–140	50 ± 38	5–90	31 ± 27	-
<i>Keratella cochlearis</i>	1–100	22 ± 34	2–210	47 ± 57	-
<i>Ascomorpha ovalis</i>	2–75	19 ± 21	0–90	27 ± 17	-
<i>Asplanchna priodonta</i>	2–20	8 ± 5	5–100	17 ± 17	-
<i>Conochilus unicornis</i>	2–10	5 ± 3	5–190	36 ± 49	-
<i>Polyarthra vulgaris</i>	2–17	5 ± 5	5–30	10 ± 6	-
<i>Microcyclops hyalinus</i>	2–22	10 ± 4	0–2	0 ± 1	-

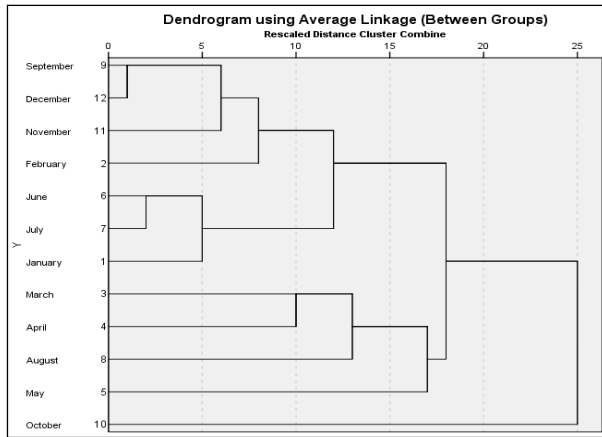


Figure 2. Hierarchical cluster analysis of zooplankton assemblages (Littoral region).

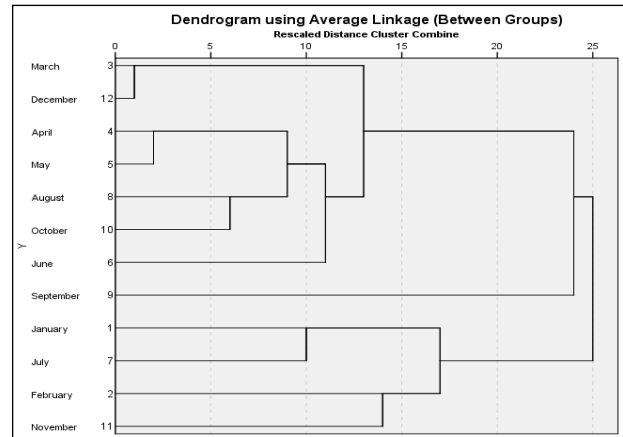


Figure 3. Hierarchical cluster analysis of zooplankton assemblages (Limnetic region).

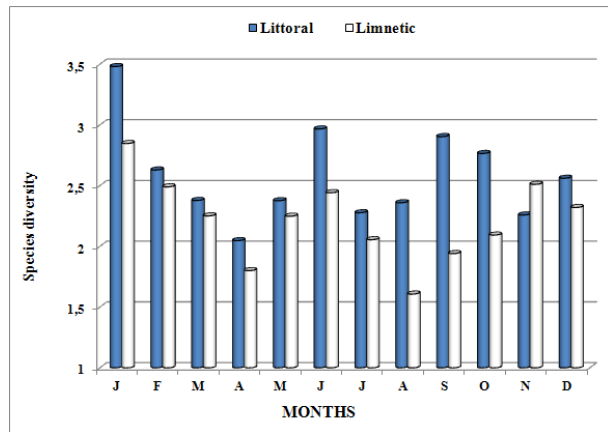


Figure 4. Monthly variations of zooplankton species diversity

inversely influenced by phosphate ( $r_2 = -0.688$ ,  $p = 0.0279$ ) at the limnetic region, and zooplankton ( $r_2 = 0.697$ ,  $p = 0.0251$ ) and Rotifera ( $r_2 = 0.679$ ,  $p = 0.0308$ ) richness is positively correlated with dissolved organic matter at the littoral region. Cladocera abundance is inversely influenced by free carbon dioxide ( $r_1 = -0.730$ ,  $p = 0.0165$ ) and nitrate ( $r_1 = -0.691$ ,  $p = 0.0251$ ); Rotifera abundance by specific conductivity ( $r_1 = -0.667$ ,  $p = 0.0351$ ) at the littoral region; and the latter is positively correlated with water abundance ( $r_2 = 0.697$ ,  $p = 0.0251$ ) at the limnetic region. Brachi-onidae is inversely influenced by transparency ( $r_1 = -0.784$ ,  $p = 0.0073$ ) and specific conductivity ( $r_1 = -0.690$ ,  $p = 0.0272$ ) and positively influenced by sulphate ( $r_1 = 0.744$ ,  $p = 0.0136$ ) at the littoral

region; it is positively influenced water temperature ( $r_2 = 0.681$ ,  $p = 0.0302$ ) and sulphate ( $r_2 = 0.772$ ,  $p = 0.0089$ ) and inversely influenced by transparency ( $r_2 = -0.721$ ,  $p = 0.0186$ ), total alkalinity ( $r_2 = -0.760$ ,  $p = 0.0189$ ) and calcium ( $r_2 = -0.732$ ,  $p = 0.0161$ ); and Chydoridae is positively ( $r_2 = 0.859$ ,  $p = 0.0016$ ) influenced by dissolved organic matter at the limnetic region. *Keratella cochlearis* recorded inverse correlation with transparency ( $r_1 = -0.759$ ,  $p = 0.0109$ ) and specific conductivity ( $r_1 = -0.673$ ,  $p = 0.033$ ) and is positively influenced by sulphate ( $r_1 = 0.736$ ,  $p = 0.0152$ ); *Ascomorpha ovalis* is positively influenced by total alkalinity ( $r_1 = 0.771$ ,  $p = 0.009$ ), total hardness ( $r_1 = 0.772$ ,  $p = 0.0089$ ) and dissolved organic matter ( $r_1 = 0.716$ ,  $p = 0.0199$ ) and calcium ( $r_1 = 0.695$ ,  $p = 0.0263$ ); and *Asplanchna priodonta* is positively influenced by dissolved oxygen ( $r_1 = 0.838$ ,  $p = 0.0025$ ), total alkalinity ( $r_1 = 0.883$ ,  $p = 0.0007$ ), total hardness ( $r_1 = 0.932$ ,  $p < 0.0001$ ), calcium ( $r_1 = 0.914$ ,  $p = 0.0002$ ), and magnesium ( $r_1 = 0.767$ ,  $p = 0.0096$ ), and inversely by sulphate ( $r_1 = -0.775$ ,  $p = 0.0085$ ) at the littoral region. *Ascomorpha ovalis* is inversely influenced by dissolved oxygen ( $r_2 = -0.689$ ,  $p = 0.027$ ); *Keratella cochlearis* is positively influenced by water temperature ( $r_2 = 0.690$ ,  $p = 0.027$ ) and sulphate ( $r_2 = 0.775$ ,  $p = 0.008$ ) and is inversely influenced by transparency ( $r_2 = -0.716$ ,  $p = 0.011$ ), total alkalinity ( $r_2 = -0.764$ ,  $p = 0.010$ ) and calcium ( $r_2 = -0.738$ ,  $p = 0.015$ ); and *Asplanchna priodonta* is positively influenced

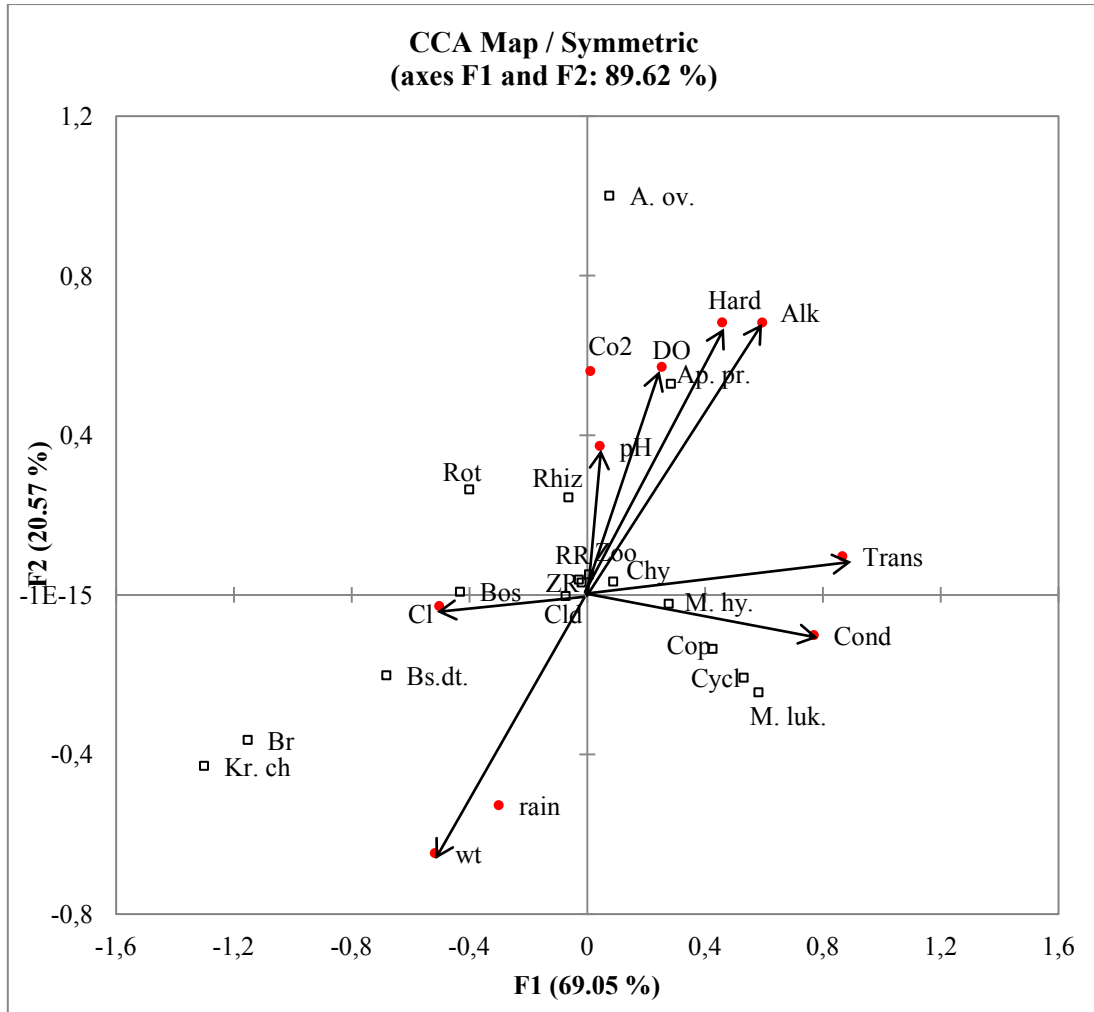


Figure 5. CCA coordination biplot of zooplankton and abiotic factors (Littoral region).

**Abbreviations: Abiotic factors:** Alk (alkalinity), Cl (Chloride), Cond (specific conductivity), Co2 (free carbon dioxide, DO (dissolved oxygen), rain (rainfall), Trans (transparency), Hard (hardness), pH (hydrogen-ion concentration), wt (water temperature). **Biotic factors:** A. ov. (*Ascomorpha ovalis* abundance), Ap. pr. (*Asplanchna priodonta* abundance), Bos (Bosminidae abundance), Br (Brachionidae abundance), Bs. dt. (*Bosminopsis deitersi* abundance), Chy (Chydoridae abundance), Cld (Cladocera abundance), Clr (Cladocera richness), Cop (Copepoda abundance), Cycl (Cyclopidae abundance), Kr. ch. (*Keratella cochlearis* abundance), M. hy. (*Microcyclops hyalinus* abundance), M. luk. (*Mesocyclops leuckarti* abundance), Rot (Rotifera abundance), RR (Rotifera richness), Rz (Rhizopoda abundance), Zoo (Zooplankton abundance), ZR (Zooplankton richness).

by total alkalinity ( $r_2 = 0.787$ ,  $p = 0.007$ ), total hardness ( $r_2 = 0.812$ ,  $p = 0.0043$ ) and sulphate ( $r_2 = 0.791$ ,  $p = 0.006$ ) at the limnetic region. The Canonical correspondence analysis (CCA) with

10 abiotic factors registered cumulative influence of 89.62 and 74.79%, along axis 1 and 2, on zooplankton assemblages at the littoral and limnetic regions, respectively (Figs. 5–6).

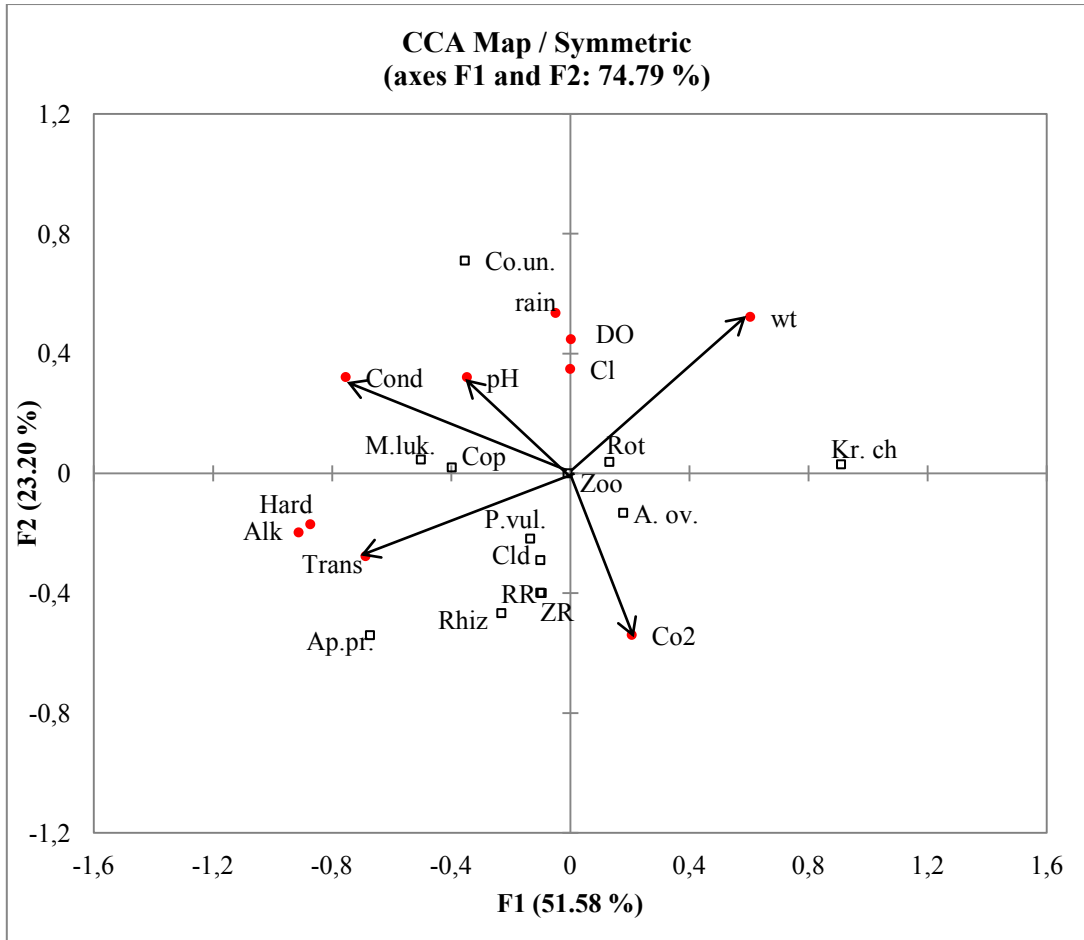


Figure 6. CCA coordination biplot of zooplankton and abiotic factors (Limnetic region)

**Abbreviations: Abiotic factors:** Alk (alkalinity), Cl (Chloride), Cond (specific conductivity), Co2 (free carbon dioxide), DO (dissolved oxygen), rain (rainfall), Trans (transparency), Hard (hardness), pH (hydrogen-ion concentration), wt (water temperature). **Biotic factors:** A. ov. (*Ascomorpha ovalis* abundance), Ap. pr. (*Asplanchna priodonta* abundance), Bos (Bosminidae abundance), Br (Brachionidae abundance), Chy (Chydoridae), Cld (Cladocera abundance), CIR (Cladocera richness), Co.un. (*Conochilus unicornis* abundance), Cop (Copepoda), Cycl (Cyclopidae abundance), Kr. ch. (*Keratella cochlearis* abundance) M. hy. (*Microcyclops hyalinus*), M. luk. (*Mesocyclops leuckarti* abundance), P. vul (*Polyarthra vulgaris*), Rot (Rotifera abundance), RR (Rotifera richness), Rz (Rhizopoda abundance), Zoo (Zooplankton abundance), ZR (Zooplankton richness).

Table 3: ANOVA indicating significance of abiotic and biotic factors

Parameters	Regions	Months
<b>Abiotic factors</b>		
Water temperature	-	$F_{11,23}=233.294, P=2.19E-11$
Transparency	$F_{1,23} = 17.742, P = 0.001$	$F_{11,23} = 10.871, P = 0.0002$
pH	-	-
Specific conductivity	-	$F_{11,23} = 11.1508, P = 0.0002$
Dissolved oxygen	-	-
Free Carbon dioxide	$F_{1,23}=73.565, P= 3.35E-06$	-
Total Alkalinity	$F_{1,23} = 23.683, P = 0.0005$	$F_{11,23} = 30.097, P = 1.31E-06$

Parameters	Regions	Months
<b>Abiotic factors</b>		
Total Hardness	$F_{1,23} = 30.644, P = 0.0002$	$F_{11,23} = 43.616, P = 1.87E-07$
Calcium	-	$F_{11,23} = 31.712, P = 9.99E-07$
Magnesium	-	$F_{11,23} = 26.706, P = 2.44E-06$
Chloride	-	$F_{11,23} = 6.0970, P = 0.0028$
Phosphate	-	$F_{11,23} = 8.972, P = 0.0005$
Sulphate	-	$F_{11,23} = 30.302, P = 1.27E-06$
Nitrate	-	$F_{11,23} = 15.625, P = 3.68E-05$
Dissolved organic matter	$F_{1,23} = 31.132, P = 0.0002$	$F_{11,23} = 3.893, P = 0.016$
<b>Biotic factors</b>		
<b>Richness</b>		
Zooplankton	$F_{1,23} = 129.717, P = 1.99E-07$	$F_{11,23} = 5.545, P = 0.0042$
Rotifera	$F_{1,23} = 23.862, P = 0.0004$	-
<b>Abundance</b>		
Zooplankton	-	-
Rotifera	$F_{1,23} = 9.323, P = 0.011$	-
Copepoda	$F_{1,23} = 168.163, P = 5.22E-08$	$F_{11,23} = 3.098, P = 0.036$
Cladocera	$F_{1,23} = 168.163, P = 5.22E-08$	$F_{11,23} = 3.820, P = 0.018$
Zooplankton species diversity	$F_{1,23} = 13.684, P = 0.003$	$F_{11,23} = 3.631, P = 0.021$
<b>Important families</b>		
Cyclopidae	$F_{1,23} = 8.987, P = 0.012$	$F_{11,23} = 3.850, P = 0.017$
Brachinoidea	$F_{1,23} = 5.478, P = 0.039$	-
Bosminidae	$F_{1,23} = 5.110, P = 0.045$	-
Chydoridae	$F_{1,23} = 54.397, P = 1.4E-05$	-
<b>Important species</b>		
<i>Mesocyclops leuckarti</i>	$F_{1,23} = 4.314, P = 0.013$	-
<i>Keratella cochlearis</i>	$F_{1,23} = 6.157, P = 0.030$	$F_{11,23} = 6.973, P = 0.002$
<i>Ascomorpha ovalis</i>	-	-
<i>Asplanchna priodonta</i>	$F_{1,23} = 8.564, P = 0.012$	$F_{11,23} = 3.105, P = 0.025$

(-) indicates insignificant variations

## DISCUSSION

The sub-tropical Nongmahir reservoir is characterized by soft, slightly acidic – circum neutral and calcium poor waters with low specific conductivity, chloride and nutrients. Low specific conductivity is attributed to leached and weathered nature of rocks and soils because of high rainfall in NEI (Sharma 1995) and the lowered buffering capacity of the de-mineralized waters (Steinitz-Kannan *et al.* 1983). ANOVA indicated significant variations of free carbon dioxide between stations; transparency, total alkalinity, total hardness and dissolved organic matter indicated significant variations between regions and months, while water temperature, specific conductivity, calcium, magnesium, chloride, phosphate, nitrate and sulphate recorded significant monthly variations. In all 12 abiotic factors registered significant monthly variations and only 5

factors registered significant variations between the regions; the differences are hypothesized to habitat diversity of the sampled regions. This study depicted decreased transparency, magnesium, sulphate and nitrate, and relative increase in specific conductivity, free carbon dioxide, total alkalinity, total hardness, calcium, phosphate and nitrate than earlier preliminary report (Sharma & Lyngskor 2003).

Fifty-six species belonging to 37 genera and 22 families observed vide our study revealed one of the biodiverse zooplankton assemblage known from the tropical and subtropical lacustrine environments of India; this salient feature is attributed to overall environmental heterogeneity of Nongmahir reservoir. Our remarks are affirmed by higher richness known than the reports from lakes and reservoirs of Andhra Pradesh (Sharmila & Shameem 2017), Karnataka (Hulyal & Kaliwal

2008, Kudari & Kanamadi 2008, Rajashekar *et al.* 2008, Majagi & Vijaykumar 2009, Shiva-shankar & Venkataramana 2013, Ramalingappa *et al.* 2015, Anita *et al.* 2019, Basawarajeshwari 2019, Majagi *et al.* 2019), Kashmir (Khan 1987, Raina & Vass 1993, Ahangar *et al.* 2012, Jeelani & Kaur 2014), Madhya Pradesh (Khandayat & Singh 2019), Meghalaya (Sharma 1995, Das *et al.* 1996, Sharma & Lyngdoh 2004), Mizoram (Sharma & Pachuau 2013), Rajasthan (Shwetanshumala & Sharma 2020), Tamil Nadu (Manickam *et al.* 2017, 2018) and Uttarakhand (Negi & Pant 1983, Mishra *et al.* 2010, Malik & Panwar 2016, Sharma & Kumari 2018, Singh & Sharma 2020), and water bodies of Nepal (Tiwari & Chhetry 2009), Bangladesh (Islam & Chowdhury 2013), Bhutan (Sharma and Bhattarai 2005) and Myanmar (Twin & Aung 2019). This study also registered a distinct two-fold richness increase than our earlier report (Sharma & Lyngskor 2003). The reports of 56 and 41 species, with 84.5% community similarity, depicted zooplankton homogeneity amongst from the two regions. Rotifera, the most speciose group, highlighted paucity of the Brachionidae and *Brachionus* spp. in slightly acidic – circum neutral waters concurrent with the reports of Sharma (1995), Sharma & Pachuau (2013) and Sharma *et al.* (2016). Peak rotifer (31 species) richness noted during January from the littoral region depicted speciose constellation. The rotifers recorded higher richness than known from lacustrine environs of Meghalaya (Sharma 1995, Sharma & Lyngdoh 2004), Mizoram (Sharma & Pachuau 2013), Kashmir (Raina & Vass 1993, Wani & Subla 1995, Jeelani & Kaur 2014, Shah *et al.* 2017, Jamila, 2018), Uttarakhand (Inaotombi *et al.* 2016), Bangladesh (Islam & Chowdhury 2013) and Myanmar (Twin & Aung 2019).

Zooplankton richness followed oscillating monthly spatial variations; higher richness at the littoral > the limnetic region is hypothesized to greater habitat diversity of the former region. Peak consortium / sample of 52 species at the littoral region during January (winter) collection supported habitat diversity assertion; such assemblage is attributed to the possibility of co-

existence of speciose constellation as hypothesized by MacArthur (1965). Zooplankton registered 57.6–85.7% and 51.1–88.9% community similarities with peak values between September–December and March–December and thus depicted heterogeneity at the two regions, respectively. This generalization is supported by 61–70% and 71–80% similarities in ~36% and ~55% instances at the littoral region, while the limnetic region recorded 51–60%, 61–70% and 71–80% similarities in ~20%, ~42% and ~34%. The hierarchical cluster analysis indicated closer affinities between September–December > June–July assemblages while October collection indicated peak divergence at the littoral region. The limnetic region showed high affinity between March–December > April–May and maximum divergence during September collections. Overall variations in cluster groupings endorsed spatial heterogeneity amongst the two regions. Rotifera influenced zooplankton richness at the littoral ( $r_1 = 0.975$ ,  $p < .0001$ ) and limnetic ( $r_2 = 0.918$ ,  $p = 0.0002$ ) regions.

Zooplankton indicated low abundance with wider variations at the limnetic than the littoral region. Low abundance is attributed to ‘soft’ waters with ‘low ionic concentrations’ of Nongmahir reservoir; our results thus concurred with the reports, from waters with identical features, from Meghalaya (Sharma 1995), Manipur (Sharma 2011a), Assam (Sharma & Sharma 2012, Sharma & Noroh 2020), and Mizoram (Sharma & Pachuau 2013) states of NEI, and from Bhutan (Sharma & Bhattarai 2005). Zooplankton comprised subdominant component of net plankton at the two regions; this generalization concurred with the reports from Assam (Sharma & Hatimuria 2017), Himachal Pradesh (Jindal & Prajapat 2005, Jindal & Thakur 2014), Meghalaya (Sharma 1995, Sharma & Lyngdoh 2003) and Mizoram (Sharma & Pachuau 2013). We recorded a distinct increase in zooplankton abundance than known from the sampled reservoir (Sharma and Lyngskor, (2003) and it is broadly concurrent with the reservoir of Mizoram (Sharma & Pachuau 2013). This study showed oscillating and differential spatial density variations; the latter is

affirmed by higher abundance at the limnetic > littoral region from April–September, while the littoral > limnetic pattern was noted from January–March and October–December. Peak April abundance, at both the regions, and maxima during August concurred with the report from Uttarakhand (Negi & Pant 1983) and monsoon maxima agreed with the report from Myanmar (Twin & Aung 2019). Besides, peak agreed with summer peaks from Andhra Pradesh (Sharmila & Shameem 2017), Karnataka (Hulyal & Kaliwal 2008, Majagi & Vijaykumar 2009, Shivashankar & Venkataramana 2013, Anita *et al.* 2019; Majagi *et al.* 2019, Basawarajeshwari 2019), Tamil Nadu (Manickam *et al.* 2017, 2018) but differed from winter peaks known from Madhya Pradesh (Khandayat & Singh 2019) and Uttarakhand (Sharma & Pant 1984, Malik & Panwar 2016, Singh & Sharma 2020). We observed differential spatial importance of Copepoda > Rotifera at the littoral region but with no overall significant influence on zooplankton. On the contrary, Rotifera ( $r_2 = 0.942$ ,  $p < 0.0001$ ) > Copepoda ( $r_2 = 0.726$ ,  $p = 0.0174$ ) contributed to zooplankton abundance at the limnetic region with the former indicating importance vs. August maxima, while Rotifera > Copepoda contributed to peak during April.

Zooplankton depicted spatial differences in quantitative importance of *Mesocyclops leuckarti* > *Keratella cochlearis* > *Ascomorpha ovalis* > *Microcyclops hyalinus* at the littoral, and of *Keratella cochlearis* > *Conochilus unicornis* > *Mesocyclops leuckarti* > *Ascomorpha ovalis* > *Asplanchna priodonta* > *Polyarthra vulgaris* at the limnetic region. We categorize these as ‘specialist’ species in contrast to the rest of ‘generalist’ species with lower densities. Following MacArthur’s (1965) explanation, it is thus hypothesized that Nongmahir reservoir has resources for utilization by fewer ‘specialist’ and majority of ‘generalist’ species. *Mesocyclops leuckarti* contributed to zooplankton peak in April with *Microcyclops hyalinus* > *Ascomorpha ovalis* > *Asplanchna priodonta* > *Chydorus sphaericus* and *Keratella cochlearis* contributed to August maxima with *Ascomorpha ovalis* > *Polyarthra*

*vulgaris* > *Bosminopsis deitersi* > *Conochilus unicornis* > *Mesocyclops leuckarti* at the littoral region. Besides, *Conochilus unicornis* > *Mesocyclops leuckarti* influenced April peak at the limnetic region with *Ascomorpha ovalis* > *Asplanchna priodonta* > *K. cochlearis*, while *K. cochlearis* influenced August maxima with *Asplanchna ovalis* > *B. deitersi* > *M. leuckarti*.

The occurrence of ‘specialist’ species agreed with the report from Mizoram (Sharma & Pachau (2013) but differed from ‘generalist’ nature of species known from reservoirs of Meghalaya (Sharma 1995, Sharma & Lyngskor 2003), the floodplain lakes of NEI (Sharma, 2011b, 2011b, Sharma & Sharma 2011, 2020, Sharma & Noroh 2020), and lakes of Himachal Pradesh (Jindal & Prajapat 2005; Jindal & Thakur 2014) and Uttarakhand (Malik & Panwar 2016; Singh & Sharma (2020).

Copepoda recorded spatial monthly density variations at the littoral > limnetic regions; ANOVA registered significant variations between regions and months. The quantitative dominance of copepods at the littoral region concurred with the results of Negi & Pant (1983), Das *et al.* (1996), Sharma & Hussain (2001), Sharma & Pachau (2013), Malik & Panwar (2016) and Sharma & Pant (1984) at Bhimtal Lake of Uttarakhand. The relatively lower abundance at the limnetic region however, agreed with the reports of Sharma (1995, 2011a), Sharma & Sharma (2012), Ramalingappa *et al.* (2015), Sharma & Noroh (2020) and Singh & Sharma (2020).

This group recorded distinctly higher abundance than the earlier report from Nongmahir reservoir (Sharma & Lyngskor 2003). Copepoda recorded pre-monsoon peaks at the littoral and limnetic regions and autumn maxima at the littoral region; the former concurred with the reports of Ramalingappa *et al.* (2015) and Sharmila & Shameem (2017). Cyclopidae contributed to copepod abundance ( $r_1 = 0.994$ ,  $p < 0.0001$ ;  $r_2 = 0.971$ ,  $p < 0.0001$ ) at the two regions; recorded significant density variations between

regions and months (vide ANOVA). This family followed monthly density variations identical to Copepoda with peaks during pre-monsoon at the littoral and limnetic regions and autumn maxima at the littoral region. *Mesocyclops leuckarti* influenced Copepoda abundance ( $r_1=0.989$ ,  $p<0.0001$ ;  $r_2=0.973$ ,  $p<0.0001$ ) at the two regions, while *Microcyclops hyalinus* influenced at the littoral region ( $r_2=0.853$ ,  $p=0.0017$ ). Cyclopidae significance is attributed to the prevalence of stable environmental conditions for these 'k-strategists' as suggested by Allen (1976). The occurrence of nauplii, throughout the study, indicated periods of active reproduction concurrent with the reports of Sharma & Lyngdoh (2004), Sharma & Pachuau (2013) and Sharma & Noroh (2020).

Rotifera recorded significant spatial density variations between the two regions (vide ANOVA); this is affirmed by quantitative dominance of Rotifera vs. zooplankton ( $r_2=0.942$ ,  $p<0.0001$ ) at the limnetic region, while this phylum comprised an important component at the littoral region. Our study indicated higher rotifer abundance than known from the sub-tropical environs of NEI (Sharma 1995, Das *et al.* 1996, Sharma & Lyngdoh 2004), while overall Rotifera importance also concurred with reports from sub-tropical lakes of Kashmir (Jyoti & Sehgal 1979, Khan 1987, Wani & Subla 1995, Jamila 2018), Uttarakhand (Negi & Pant 1983; Sharma & Pant 1984), Tamil Nadu (Manickam *et al.* 2017) and the floodplain lakes of NEI (Sharma 2011a, 2011b, Sharma & Sharma 2008, 2011, 2012, Sharma & Noroh 2020).

Our results, however, marked a distinct contrast to poor abundance recorded earlier from the sampled reservoir (Sharma & Lyngskor 2003). Rotifera affirmed differential spatial variations vs. maxima during spring and peak in monsoon (August) at the littoral, and the limnetic region recorded maxima in pre-monsoon (April) and peak in monsoon (August). Both pre-monsoon maxima and monsoon peaks agreed with the report of Ramalingappa *et al.* (2015), while pre-monsoon maxima corresponded with summer peaks reported by Paulose & Meheshwari (2007),

Manickam *et al.* (2017), Shah *et al.* (2017), Sharmila & Shameem (2017), Jamila (2018) and Singh & Sharma (2020). Brachionidae registered significant spatial density variations between regions (vide ANOVA); it showed importance from July–August (peak in July) and from July–October (peak in August) at the two regions, respectively but contributed to Rotifera abundance ( $r_1=0.681$ ,  $p=0.0302$ ) at the littoral region. *Keratella cochlearis* recorded density variations between regions and months (vide ANOVA) with peaks during July and August at the two regions, respectively but contributed to Brachionidae ( $r_1=0.999$ ,  $p<0.0001$ ) at the limnetic region.

Cladocera, sub-dominant group, indicated significant density variations between regions and months (vide ANOVA). It indicated higher abundance at the former region than the reports from Meghalaya (Sharma 1995, Das *et al.* 1996, Sharma & Lyngdoh 2004), Mizoram (Sharma & Pachuau 2013) and Uttarakhand (Negi & Pant 1983). The cladocerans followed oscillating monthly variations at both regions; recorded peak during June and maxima during winter at the littoral region and peak during June at the limnetic region. The peaks concurred with the reports of Ramalingappa *et al.* (2015), Sharmila & Shameem (2017), Sharma & Noroh (2020), Malik & Panwar (2016) and Singh & Sharma (2020) and while winter maxima agreed with the reports from two floodplain lakes of Manipur (Sharma 2011a). Bosminidae and Chydoridae indicated significant spatial variations between the regions (vide ANOVA). *Bosminopsis deitersi* contributed to abundance and peak of Cladocera ( $r_1=0.668$ ,  $p=0.0348$ ) and Bosminidae ( $r_1=0.942$ ,  $p<0.0001$ ) at the littoral region, while Bosminidae ( $r_2=0.818$ ,  $p=0.0038$ ) influenced Cladocera abundance at the limnetic region. The other zooplankton groups, Rhizopoda and Ostracoda recorded very poor abundance in this study.

Zooplankton registered significant species diversity ( $H'$ ) variations between regions and months (vide ANOVA). Higher diversity at the littoral region > limnetic region, except in November (autumn), is hypothesized to greater



habitat heterogeneity at the former region. Peak diversity during winter (January) corresponded with peak zooplankton richness; and  $H'$  values  $> 2.9$  and  $> 2.5$  were noted during June (pre-monsoon) and September (monsoon), and during November (autumn) at the two regions, respectively. The diversity followed oscillating patterns of monthly variations at the two regions. It is influenced by richness and equitability of species concurrent with the remarks of Sager and Hasler (1969) at the littoral region as affirmed by positive influence by richness of zooplankton ( $r_1 = 0.759$ ,  $p = 0.0109$ ) and Rotifera ( $r_1 = 0.753$ ,  $p = 0.0119$ ), and evenness ( $r_1 = 0.956$ ,  $p < 0.0001$ ). On the other hand, the diversity is positively influenced by evenness ( $r_2 = 0.949$ ,  $p < 0.0001$ ) but inversely by zooplankton ( $r_2 = -0.669$ ,  $p = 0.0349$ ), Rotifera ( $r_2 = -0.861$ ,  $p = 0.0014$ ) and Brachionidae ( $r_2 = -0.704$ ,  $p = 0.0231$ ) abundance at limnetic region.

The concurrence of high diversity with relatively lower densities of majority of species, at both sampling regions, as supported by positive correlations with evenness, is attributed to ability of co-existence of various species in combination with high micro- and macro-scale habitat heterogeneity as hypothesized by Segers (2008). We recorded wide variations in zooplankton dominance with peak values during April and August at the littoral and limnetic regions, respectively; high values during March, July and November at the former region; and during April, September and October at the limnetic region. These periods corresponded with zooplankton assemblages dominated by 'specialist' species (Whittaker 1965), while lower dominance during rest of the months is shared by a large number of 'generalist' species (Osborne *et al.* 1976). Further, dominance ( $r_1 = -0.893$ ,  $p = 0.0006$ ;  $r_2 = -0.781$ ,  $p = 0.0076$ ) recorded inverse correlation with zooplankton diversity at both the regions. Equitable occurrence and low densities of 'generalist' species resulted in high evenness concurrent with periods of high species diversity, while occurrence of 'specialist' species culminated in high evenness in selective months. These generalizations are supported by positive correlation of evenness vs. diversity ( $r_1 =$

$0.956$   $p < 0.0001$ ;  $r_2 = 0.949$   $p < 0.0001$ ) and inverse correlation with dominance ( $r_1 = -0.961$   $p < 0.0001$ ;  $r_2 = -0.889$ ,  $p = 0.0006$ ) at both the sampling regions, respectively.

Our study registered limited and differential spatial influence of individual abiotic parameters on richness and abundance of zooplankton and constituent groups at the two regions. These remarks are endorsed by positive correlation of dissolved organic matter on zooplankton and Rotifera richness at the littoral region, while the latter is inversely influenced by phosphate at the limnetic region. Further, Rotifera abundance is positively correlated with water temperature at the limnetic region, and Cladocera abundance is inversely influenced by free carbon dioxide and nitrate, and is inversely influenced by specific conductivity at the littoral region. The limited influence on richness concurred with the results of Sharma & Sharma (2012), while that on abundance on zooplankton and constituent groups corresponded with the reports of Sharma (2011a), Sharma & Sharma (2011a, 2020) and Sharma & Noroh (2020).

The differential spatial significance also holds valid for notable families and 'specialist' species. Brachionidae is inversely influenced by transparency and specific conductivity and positively influenced by sulphate at the littoral region; it is positively influenced water temperature and sulphate and inversely influenced by transparency, total alkalinity and calcium at the limnetic region; Bosminidae is positively correlated with transparency and chloride; and Chydoridae is positively influenced by dissolved organic matter at the limnetic region. *Keratella cochlearis* recorded inverse correlation with transparency and specific conductivity and is positively influenced by sulphate; *Ascomorpha ovalis* is positively influenced by total alkalinity, total hardness alkalinity and dissolved organic matter; and *Asplanchna priodonta* is positively influenced by dissolved oxygen, total alkalinity, total hardness, calcium, and inversely by sulphate at the littoral region. *A. ovalis* is inversely influenced by dissolved oxygen; *K. cochlearis* is positively influenced by

water temperature and sulphate and inversely influenced by transparency, total alkalinity and calcium; and *A. priodonta* is positively influenced by total alkalinity, total hardness and sulphate at the limnetic region. In general, the positive correlations of Rotifera, Brachionidae and *K. cochlearis* with water temperature at the limnetic region concurred with the periods of high abundance of these taxa.

The canonical correspondence analysis (CCA) with 10 abiotic factors registered high cumulative influence on the littoral (89.62%) and limnetic (74.79%) zooplankton, constituent groups, and notable families and species along the first two axes. CCA coordination biplot at the littoral region indicated ~ 69% and ~20% influence of abiotic factors along axis 1 and 2, respectively. Water temperature and chloride influenced richness of zooplankton and Cladocera abundance; total alkalinity, total hardness influenced abundance of zooplankton and *Asplanchna priodonta*; specific conductivity influenced abundance of *Microcyclops hyalinus*; total alkalinity and transparency influenced Chydoridae abundance at the littoral region. CCA coordination biplot at the limnetic region indicated ~ 51% and ~23% influence of abiotic factors along axis 1 and 2, respectively. Water temperature influenced Rotifera density; specific conductivity and pH influenced abundance of Copepoda and *Mesocyclops leuckarti*; and transparency influenced zooplankton abundance at the limnetic region. Our study thus highlighted importance of cumulative influence over individual influence of abiotic factors, while the impact of fish predation in this reservoir yet needs to be assessed. High cumulative influence concurred with 84.8% cumulative variance reported from a reservoir of Mizoram (Sharma & Pachau 2013) but differed from lower cumulative influence observed from certain floodplain lakes of NEI (Sharma 2011a, Sharma & Sharma 2012, Sharma & Hatimuria 2017, Sharma & Noroh 2020).

Our results caution on application of  $Q_B/T$  trophic status quotient (Sladeczek 1983) in view is distinct paucity of *Brachionus* spp. in soft and

slightly acidic – circum neutral waters of Nongmahir reservoir. We, however, consider Shannon Weiner diversity index as a suitable option for assessing the health of aquatic biotopes with values between 1–3 as indicator of moderately polluted condition and less than 1.0 indicating heavy polluted condition (Wilhm and Dorris 1968, Masson 1998, Datta, 2001). The mean diversity values recorded vide this study depicted moderately polluted ('meso-trophic') nature, while monthly variations at the limnetic region particularly during April, August and September reflected 'meso-eutrophic' nature of Nongmahir reservoir.

To sum up, our report on one of the speciose zooplankton assemblage from the (sub) tropical lacustrine environs of India and peak consortium of 52 species/sample depicted regional biodiversity interest and overall environmental heterogeneity of Nongmahir reservoir located in the Indo-Myanmar hot-spot. Low abundance of zooplankton attributed to 'soft' and demineralized waters; the differential spatial patterns of composition, richness, abundance of zooplankton, constituent groups and important taxa, and moderate species diversity with variations of dominance and equitability indicating habitat heterogeneity of the two regions; and resource utilization by both by 'specialist' and 'generalist' species are noteworthy features. Importance of high overall cumulative influence over individual influence of abiotic factors at the two sampled regions is noteworthy, while the impact of fish predation in this reservoir is required to be assessed. The variations recorded in different aspects of zooplankton vs. the preliminary survey of June 1995–May 1996 asserted notable temporal variations. In general, this study is an important contribution to zooplankton diversity of lacustrine environs of India and the subtropical reservoirs of NEI in particular.

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### Appendix I. Monthly variations in abundance (ind. l<sup>-1</sup>) of zooplankton (Littoral region)

Zooplankton↓ Months→	J	F	M	A	M	J	J	A	S	O	N	D
ROTIFERA												
<i>Ascomorpha ovalis</i>	18	75	50	12	10	5	7	20	5	2	5	14
<i>Asplanchna priodonta</i>	8	20	15	12	8	7	3	2	1	4	5	5
<i>B. quadridentatus</i>	3	2	1	1	0	0	0	0	2	3	2	1
<i>Euchlanis dilatata</i>	1	0	0	1	0	0	0	1	0	0	0	1
<i>Collotheca ornata</i>	1	2	0	0	0	1	0	1	0	1	0	0
<i>Conochilus unicornis</i>	10	8	6	5	2	2	5	10	8	2	2	2
<i>Colurella obtusa</i>	3	2	0	0	0	1	0	0	0	0	0	0
<i>Keratella cochlearis</i>	1	1	2	5	5	20	100	94	23	14	1	1
<i>Lepadella ehrenbergi</i>	2	0	0	1	0	0	0	1	0	0	1	0
<i>L. ovalis</i>	1	0	0	1	0	0	1	0	0	1	0	0
<i>Lepadella patella</i>	2	0	3	0	1	0	0	1	0	0	0	0
<i>Lecane bulla</i>	2	0	0	0	1	2	1	1	0	0	0	0
<i>L. closterocerca</i>	2	1	1	0	0	2	2	3	2	1	1	2
<i>L. curvicornis</i>	3	0	0	1	1	0	2	0	1	1	1	2
<i>L. hornemanni</i>	2	0	0	0	0	2	0	0	0	0	1	0
<i>L. leontina</i>	4	0	0	1	0	0	0	1	2	0	0	1
<i>L. luna</i>	2	0	0	0	0	1	0	0	1	2	1	0
<i>L. lunaris</i>	3	2	1	1	2	0	0	1	0	1	0	0
<i>L. quadridentata</i>	1	0	0	0	1	0	0	1	0	1	0	0

<i>L. stenroosi</i>	1	2	0	0	0	0	0	0	1	1	1	0
<i>Macrochaetus collinsi</i>	1	0	0	0	0	1	1	0	0	0	0	0
<i>Mytilina ventralis.</i>	2	2	1	0	0	2	2	1	1	0	0	1
<i>Platyonus patulus</i>	2	1	0	0	0	2	0	0	3	2	1	1
<i>Platyias quadricornis</i>	2	0	0	0	1	1	0	0	0	0	0	0
<i>Polyarthra vulgaris</i>	8	10	5	0	0	2	7	17	4	2	1	1
<i>Pompholyx sulcata</i>	3	3	1	1	0	1	1	1	0	2	0	0
<i>Testudinella patina</i>	2	0	0	1	2	1	0	0	2	0	1	2
<i>Trichocerca cylindrica</i>	3	1	0	2	0	0	1	0	0	0	2	1
<i>T. pusilla</i>	0	0	0	2	3	1	1	0	0	0	1	2
<i>T. similis</i>	2	0	1	1	1	1	2	2	0	0	0	0
<i>Trichotria tetractis</i>	1	0	1	0	1	0	0	0	1	0	0	1
CLADOCERA												
<i>Alona rectangula</i>	2	3	2	2	10	8	4	3	2	2	3	2
<i>Bosmina longirostris</i>	10	8	7	5	3	2	2	3	3	2	3	2
<i>Bosminopsis deitersi</i>	6	5	3	2	2	20	28	16	10	8	6	5
<i>Ceriodaphnia cornuta</i>	5	3	5	6	8	5	2	2	4	7	9	10
<i>Chydorus angustirostratus</i>	2	1	0	0	0	0	2	1	1	0	1	2
<i>C. sphaericus</i>	6	8	10	10	8	8	3	4	7	12	2	9
<i>Diaphanosoma excisum</i>	2	1	0	0	2	2	1	0	0	1	1	2
<i>D. sarsi</i>	1	1	2	2	1	1	0	2	2	0	2	3
<i>Karualona karua</i>	3	2	1	3	2	1	1	1	1	0	0	2
<i>Scapholeberis kingi</i>	3	2	1	1	1	1	3	3	0	0	2	3
COPEPODA												
<i>Mesocyclops leuckarti</i>	30	22	66	140	89	23	12	10	26	28	86	69
<i>Microcyclops hyalinus</i>	8	11	12	22	10	6	5	5	9	12	10	9
<i>Heliodyptomus contortus</i>	2	3	3	1	0	1	2	1	1	0	2	2
<i>H. viduus</i>	3	2	0	2	2	1	2	0	2	2	3	2
Nauplii	12	22	27	32	18	15	9	24	10	16	20	14
RHIZOPODA												
<i>Arcella discoidea</i>	6	3	1	0	1	1	1	0	2	0	1	1
<i>A. hemispherica</i>	2	1	0	0	2	2	1	2	1	1	2	0
<i>A. vulgaris</i>	0	2	0	1	0	0	0	2	1	0	0	1
<i>Centropyxis aculeata</i>	1	0	0	0	1	0	0	0	0	1	0	0
<i>C. eornis</i>	1	0	0	0	0	0	0	1	0	0	0	0
<i>Diffugia lebes</i>	2	0	2	1	2	1	1	0	0	1	1	0
<i>D. oblonga</i>	1	1	0	0	0	0	0	1	0	0	0	1
<i>Euglypha laevis</i>	1	0	0	0	1	1	1	0	0	1	0	0
<i>Trinema enchelys</i>	0	0	0	0	0	0	0	0	1	0	0	1
OSTRACODA	0	0	2	1	1	0	1	0	1	0	0	0
ROTIFERA	96	132	88	48	39	55	136	158	57	40	27	38
CLADOCERA	40	34	31	31	37	48	46	35	30	32	29	40
COPEPODA	55	60	108	197	119	46	30	40	48	58	121	96
RHIZOPODA	14	7	3	2	7	5	4	6	5	4	4	4
OSTRACODA	0	0	2	1	1	0	1	0	1	0	0	0
<b>ZOOPLANKTON</b>	<b>205</b>	<b>233</b>	<b>232</b>	<b>279</b>	<b>203</b>	<b>154</b>	<b>217</b>	<b>239</b>	<b>141</b>	<b>134</b>	<b>181</b>	<b>178</b>

**Appendix II.** Monthly variations in abundance (ind. l<sup>-1</sup>) of zooplankton (Limnetic region)

Zooplankton↓ Months→	J	F	M	A	M	J	J	A	S	O	N	D
<b>ROTIFERA</b>												
<i>Ascomorpha ovalis</i>	0	10	30	33	50	20	14	50	47	9	10	45
<i>Asplanchna priodonta</i>	4	45	56	32	20	15	2	4	5	6	5	8
<i>Brachionus rubens</i>	2	0	0	1	0	0	1	1	0	0	1	0
<i>B. quadridentatus</i>	0	2	0	0	0	1	0	0	1	0	0	0
<i>Collotheca ornata</i>	1	1	2	0	0	1	0	1	3	2	0	1
<i>Colurella obtusa</i>	0	2	0	0	0	0	1	0	0	0	1	0
<i>Conochilus unicornis</i>	5	7	10	190	57	40	33	30	12	15	20	10
<i>Euchlanis dilatata</i>	2	0	1	1	0	0	0	0	0	0	0	1
<i>Keratella cochlearis</i>	2	5	9	12	30	42	90	210	87	56	15	9
<i>Lepadella patella</i>	1	0	9	0	1	0	0	0	1	0	0	0
<i>Lecane bulla</i>	2	0	1	0	0	0	1	1	0	0	0	1
<i>L. curvicornis</i>	0	2	0	1	1	0	1	0	0	1	1	0
<i>L. leontina</i>	2	0	1	0	0	0	1	0	0	0	1	1
<i>L. luna</i>	1	0	0	0	1	0	0	0	2	0	0	0
<i>L. lunaris</i>	0	0	1	2	1	0	0	1	0	1	0	0
<i>L. stenroosi</i>	0	1	0	0	0	1	0	0	0	0	1	0
<i>Plationus patulus</i>	2	1	0	0	0	0	0	0	0	1	0	0
<i>Polyarthra vulgaris</i>	5	8	10	8	12	30	10	9	8	6	10	8
<i>Pompholyx sulcata</i>	3	2	5	1	8	12	6	1	0	2	0	2
<i>Testudinella patina</i>	2	0	0	0	0	0	0	0	1	1	1	0
<i>Trichocerca cylindrica</i>	2	0	0	1	0	0	0	1	0	0	0	1
<i>T. similis</i>	1	0	2	3	5	8	2	6	2	1	0	1
<i>Trichotria tetractis</i>	1	1	0	0	0	0	1	0	0	0	1	0
<b>CLADOCERA</b>												
<i>Alona rectangula</i>	2	0	1	3	1	0	1	0	1	0	0	1
<i>Bosmina longirostris</i>	3	2	1	1	5	6	1	2	4	2	5	3
<i>Bosminopsis deitersi</i>	2	5	3	6	8	15	8	12	6	3	2	2
<i>Ceriodaphnia cornuta</i>	2	3	0	2	3	5	0	2	3	3	0	2
<i>Chydorus angustirostratus</i>	0	1	0	0	0	0	0	1	0	1	0	0
<i>C. sphaericus</i>	9	6	0	1	1	3	2	1	0	1	2	0
<i>Diaphanosoma sarsi</i>	2	0	0	0	1	0	1	0	0	0	1	0
<i>Karualona karua</i>	0	0	2	0	0	0	0	0	1	0	0	1
<b>COPEPODA</b>												
<i>Mesocyclops leuckarti</i>	36	15	42	90	70	55	20	10	5	5	7	16
<i>Microcyclops hyalinus</i>	2	0	0	0	0	0	0	0	1	0	0	0
<i>Heliodiaptomus contortus</i>	3	2	0	0	0	1	0	2	0	0	1	1
Nauplii	10	18	8	32	20	33	29	17	5	3	8	5
<b>OSTRACODA</b>												
<i>Cypris sp.</i>	1	2	0	1	0	1	1	0	0	0	0	0
<b>RHIZOPODA</b>												
<i>Arcella discoides</i>	2	1	3	1	1	0	1	1	0	2	0	2
<i>Arcella hemispherica</i>	1	1	0	0	0	0	0	0	2	0	1	0
<i>A. vulgaris</i>	0	0	1	2	1	1	0	1	1	0	0	1
<i>Centropyxis aculeata</i>	1	0	0	0	0	0	0	0	0	1	0	0
<i>Diffugia lebes</i>	2	0	1	1	1	7	0	0	0	0	2	2
<i>Euglypha laevis</i>	1	1	0	0	0	0	1	0	1	0	0	0



ROTIFERA	38	87	137	285	186	170	163	315	169	101	67	88
CLADOCERA	20	17	7	13	19	29	13	18	15	10	10	9
COPEPODA	51	35	50	122	90	89	49	29	11	8	16	22
RHIZOPODA	7	3	5	4	3	8	2	2	4	3	3	5
OSTRACODA	1	2	0	1	0	1	1	0	0	0	0	0
<b>ZOOPLANKTON</b>	117	144	199	425	298	297	228	364	199	122	96	124

## Remarks on the new earthworm taxa described by Aladesida and Owa in 2015 from Nigeria (Clitellata: Megadrili)

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**Abstract.** The earthworm fauna of tropical Africa is clearly understudied. This is mainly due to the lack of local earthworm researchers. Nigeria is an exception in this regard with an excellent earthworm researcher A.O. Segun and his successor S.O. Owa describing some 30 earthworm species belonging to the family Eudrilidae. Recently, Aladesida & Owa (2015) published descriptions of four new earthworm genera and species; *Adodrilus stephana* (Megascolecidae), *Ekitidrilus alabataensis*, *Paranematogenia eyinwaensis* (Ocnerodrilidae), and *Imekodrilus hexagastricus* (Moniligastridae). Examining the type material of the new taxa deposited in the Natural History Museum, London revealed that *Adodrilus stephana* Aladesida & Owa, 2015 is a synonym of *Gordiodrilus robustus* Beddard, 1892, *Ekitidrilus alabataensis* Aladesida & Owa, 2015 represents a nomen nudum. Due to the juvenile state of the types, the names *Imekodrilus hexagastricus* Aladesida & Owa, 2015 represent a nomen dubium in the family Ocnerodrilidae and *Paranematogenia eyinwaensis* a nomen dubium in the family Eudrilidae. To prevent further nomenclatural problems, lectotypes for *Adodrilus stephana* and *Paranematogenia eyinwaensis* were designated.

**Keywords.** Africa, Annelida, Oligochaeta, lectotype, synonymy.

### INTRODUCTION

The earthworm fauna of tropical Africa is very poorly investigated compared to other tropical regions like Australia, South America or South-East Asia. This is clearly reflected by the *ca.* 600 earthworm species recorded from Africa, a low number comparing to the *ca.* 1000 species reported from South America (Fragoso & Brown 2007) or the 505 species reported from the much smaller India (Narayanan *et al.* 2017).

Thanks to the works of A.O. Segun (between 1976–1990) and S.O. Owa (1990–1998) among the tropical African countries Nigeria seems to be the best explored with its some 100 earthworm species. The earthworm fauna of this vast West African country is highly specialised; 10 of the registered 25 genera are endemic to this region. Therefore it is not surprising, that recently two

Nigerian scientists reported four new earthworm genera and species from the country: *Adodrilus stephana* (Megascolecidae), *Ekitidrilus alabataensis*, *Paranematogenia eyinwaensis* (Ocnerodrilidae), and *Imekodrilus hexagastricus* (Moniligastridae) (Aladesida & Owa 2015). The new earthworm material was collected in Southwest Nigeria (Ekiti and Ogun States). According to the original descriptions, the holotypes of the new taxa were deposited in the Natural History Museum, London.

In 2013 the first and last author had the possibility to work together on a large unidentified earthworm material collected in West Africa and also to check the type material sent by S. Owa to the Museum in 2012. As at that time neither of the label names were published, we made several notes on the earthworms in each vial and treated them as unpublished manuscript names.

In the meantime, descriptions of four new genera by Aladesida & Owa (2015) were published. As all the proposed new names were recorded as problematic or synonyms in our original notes here, we re-examined the type material and concluded that *Adodrilus stephana* Aladesida and Owa, 2015 is a synonym of the African peregrine *Gordiodrilus robustus* Beddard, 1892, *Ekitidrilus alabataensis* Aladesida and Owa, 2015 belongs also to *Gordiodrilus robustus* but the name is a nomen nudum because, due to a typesetting error its description lacks explicit indication of describing a new species (ICZN Art 16.1). *Imekodrilus hexagastricus* Aladesida and Owa, 2015 is an ocneroдрilid species reminiscent of *Nematogenia lacuum* (Beddard, 1893) however, the holotype is completely juvenile. The fourth new taxon *Paranematogenia eyinwaensis* Aladesida and Owa, 2015 belongs to the eudrilid subfamily Pareudriolinae Beddard, 1894 close to the genus *Pareudrilus* Beddard, 1894 however; due to the juvenile state of the two syntypes its exact position cannot be determined.

## MATERIAL AND METHODS

The type material deposited in the Natural History Museum, London was examined using a Nikon SMZ600 stereo microscope. According to the original description the holotypes of the new taxa from Nigeria was deposited in the Museum. Whenever we have found several specimens of a species present, lectotypes were designated to avoid further nomenclatural problems.

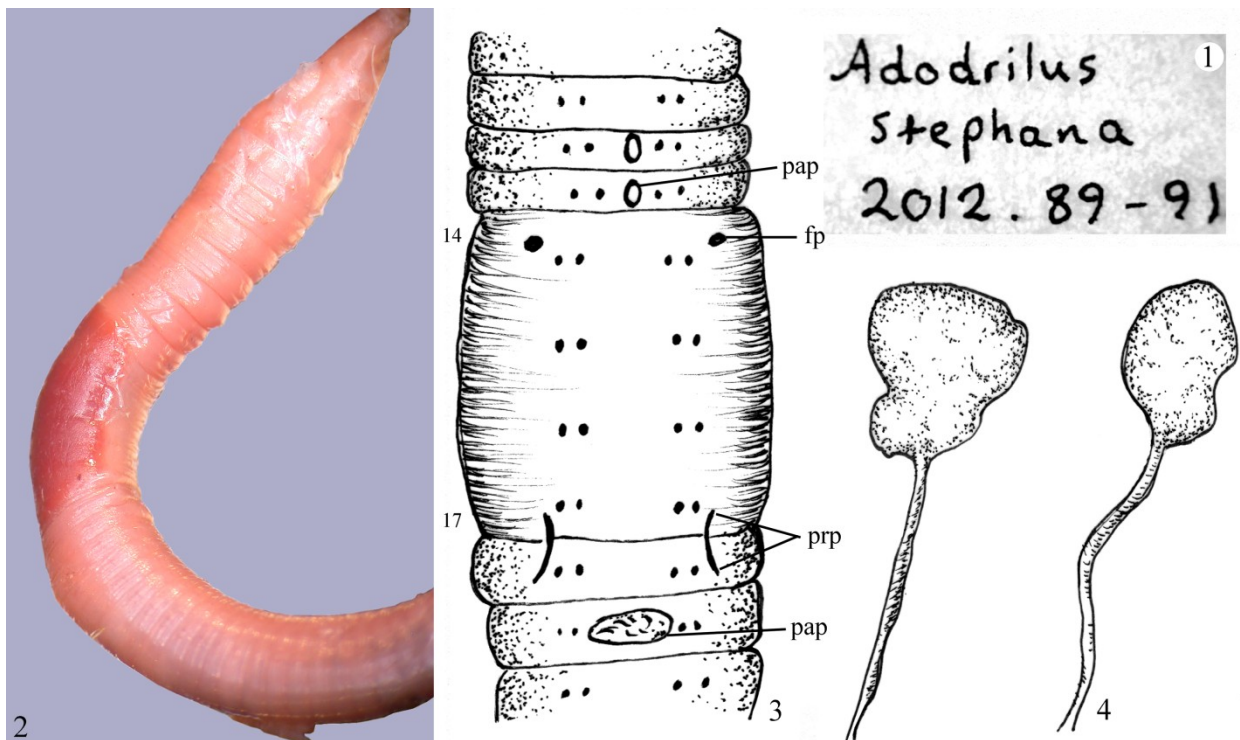
## TAXONOMY

### Family Ocneroдрilidae Michaelsen, 1900

#### *Gordiodrilus robustus* Beddard, 1892

*Adodrilus stephana* Aladesida & Owa, 2015: 102–103.  
syn. nov.

*Material examined.* *Adodrilus stephana* Aladesida & Owa, 2015 genus et sp. novo Syntypes,



Figures 1–4. *Adodrilus stephana* Aladesida & Owa, 2015. 1 = vial label, 2 = habitus from lateral view, 3 = clitellar region from ventral view, 4 = spermathecae. *fp* = female pore, *pap* = papillae, *prp* = prostate pores.

NHM2012.89–91 three clitellate specimens. Nigeria, Ekiti state, Ado-Ekiti. 8/7/2008. Leg. Adeyinka Aladesida.

<https://data.nhm.ac.uk/object/67df079f-5dce-496d-951c-d7258cd8d0de/1583798400000>

*Description.* Dimensions of the specimens 36x2 mm, segment no. 97; 41x2 mm, segment no. 96; 50x2 mm, segment no. 107. Colour preserved brownish, alive unknown. Head prolobous. First dorsal pore in 11/12. Setae closely paired, setal ratio of the longest specimen  $aa:ab:bc:cd:dd = 5:1:8.5:1:22$ . Nephridial pores not seen.

Clitellum well developed, saddle-shaped on segments 14–17. Prostatic pores on 17–18 in setal line *b* connected by straight seminal groves. Male pores not seen. Female pores small dots on 14, praesetal and lateal to *b*, *ca.* half way between *b* and *c* on the lateral edge of the clitellum. Spermathecal pores paired in 6/7–7/8 in setal line *b*. Glandular papillae small, midventral on 12, 13 and a large prominent glandular pad between *aa* on 19.

*Internal characters.* Muscular gizzard vestigial in 7 and strong in 8. Septa 5/6–7/8 thickened. Calciferous glands in 9, single, with bifid ventral projection. Excretory system holoic, avesiculate. Last pair of hearts in 11. Testes in 10, 11 covered some free sperms, vesicles one pair in 12. Ovaria large in 13. Spermathecae two pairs with a very long and thin, in some part spiral duct and large, more or less oval ampoule. Prostates small simple tubes confined to their own segments. Penial setae lacking.

*Remarks.* According to the original description „The holotype has been repositated at the British Museum of Natural History, while the syntype is at the Museum of Natural History, Olabisi Onabanjo University, Ago-Iwoye, Nigeria”. In NHM London there are 3 specimens with registration number NHM2012.89–91 which should be regarded as syntypes. As the species was described on eight specimens, a further five exemplars were deposited in the Museum of Natural History, Olabisi Onabanjo University, Ago-Iwoye, Nigeria. To avoid further problems here we

designate the largest specimen with 107 segment number as *lectotype* with registration number NHM2012.89.

The authors relegated these specimens to the family Megascolecidae, because they thought that there is only one pair of „bag-shaped” prostates in 17/18. In reality there are two pairs of highly coiled tubular prostates in 17 and 18. Also, the authors did not recognize the first pair of spermathecae in segment 7 which is usually smaller than the next ones in segment 8 and are folded under the oesophagus and if empty, hard to recognize.

The fused calciferous glands, the characteristic spermathecae and the papillae on segments 12, 13 and 19 clearly prove that these specimens belong to the local peregrine *Gordiodrilus robustus* Beddard, 1892 of the family Ocnerodrilidae.

*Ekitidrilus alabataensis* Aladesida & Owa, 2015: 105–106. **nomen nudum**

*Material examined.* *Ekitidrilus alabataensis* Aladesida & Owa, 2015 Syntypes, NHM2012.74–75 three clitellate specimens. Nigeria, Ekiti state and Ogun state; Ado-Ekiti. 8-12/7-9 2008-2009. Leg. Adeyinka Aladesida.

<https://data.nhm.ac.uk/object/579f103c-04e0-4880-a02b-0dbded201e65/1583366400000>

*Description.* Length of the largest specimen 36 mm, diameter after clitellum 1.5 mm. Segment number 93, tail missing. Length of the smaller specimen 35 mm, diameter 1.5 mm, segment no. 97. The smallest but clitellate specimen 20 mm in length and 1 mm in diameter, segment no. 89. Colour preserved brownish, alive unknown. Head prolobous. First dorsal pore in 11/12. Setae closely paired, setal ratio  $aa:ab:bc:cd:dd = 4.4:1:6.7:1:22.2$ . Nephridial pores not seen.

Clitellum saddle-shaped on segments 14–17. Prostatic pores on 17–18 in setal line *b* connected by straight seminal grooves. Male pores not seen. Female pores small dots on 14, praesetal and lateal to *b*, *ca.* half way between *b* and *c*. Spermathecal pores paired in 6/7–7/8 in setal line *b*.

Glandular papillae small, midventral on 12, 13 and a larger on 19.

*Internal characters.* Muscular gizzard small in 7 and strong in 8. Septa 5/6–7/8 slightly thickened, 8/9–11/12 moderately strengthened. Calciferous glands in 9, single, with bifid ventral projection. Excretory system holoic, avesculate. Testes, funnels, vesicles and ovaria missing. Spermathecae two pairs with a very long and thin, in some part spiral duct and small irregularly sack-shaped ampoule. Prostates small simple tubes confined to their own segments. Penial setae lacking.

*Remarks.* The worms, according to their rudimentary gizzard in 7 and a large one in 8, the unpaired calciferous gland and characteristic shape of spermathecae clearly belong to the regional peregrine *Gordiodrilus robustus*. All the two specimens possess slightly degenerated prostates and lack any sign of sperm in the spermathecae, however the clitellum were more or less developed.

Due to a printing error, the name *Ekitidrilus alabataensis* appears only in the abstract and on p. 106 in the legends of figure 3a. Seemingly the line stating the taxon as new is missing on p. 104 because, after the etymology of an other new taxon *Paranematogenia eyinwaensis* again comes the heading: "Type locality" which is Ado-Ekiti and Alabata. According to the Code of Zoological Nomenclature "All names: intention of authors to establish new nominal taxa to be explicit. Every new name published after 1999, including new replacement names (*nomina nova*), must be explicitly indicated as intentionally new" and according to Recommendation 16A: Means of explicitly indicating names as intentionally new. To avoid uncertainty about their intentions, authors proposing new names (*nomina nova*), including new replacement names, are advised to make their intentions explicit by using in headings, or at first use of new names in proposals, appropriate abbreviations of Latin terms such as "...*sp. nov.*", "...*ssp. nov.*", or some strictly equivalent expression such as "...*new species*", "*new*

*subspecies*, ..."*n. sp.*", "*n. ssp.*" (ICZN Art 16.1). As such kind of indication is missing here and also one can only guess which name the description belong to the name in the abstract and in the figure caption "*Ekitidrilus alabataensis*" should be regarded as *nomen nudum*.

Under the heading Type material, the authors write that the „*The holotype has been repositated at the British Museum of Natural History, while the syntype is at the Museum of Natural History, Olabisi Onabanjo University, Ago-Iwoye, Nigeria*” However, in the Natural History Museum, London the vial registered under No. 2012.74-75 contains 3 specimens with locality Ado-Ekiti. As in the paper the authors state that they had two clitellate specimens from Ado-Ekiti and three from Alabata, the third very small but clitellate specimen in the vial either was overlooked by the authors or accidentally one specimen from Alabata was also put into the vial sent to NHM, London.

#### Ocnerodrilidae sp. juv.

*Imekodrilus hexagastricus* Aladesida & Owa, 2015: 101–102. **nomen dubium**

*Material examined.* *Imekodrilus hexagastricus* Aladesida & Owa, 2015 Holotype, NHM2012.72 one juvenile specimen. Nigeria, Imeko. 10/9/2009. Leg. Adeyinka Aladesida.

<https://data.nhm.ac.uk/object/5c7279f6-2202-4041-a335-f6ad56317187/1583798400000>

*Description.* Length 82 mm, diameter 2 mm, segment no. 194. Colour pale pigmentation lacking. Head epilobous. First dorsal pore in 8/9. Setae closely paired, setal ratio of the longest specimen *aa:ab:bc:cd:dd* = 5:1:8.5:1:22. Nephridial pores not seen. The specimen completely juvenile, no clitellum and genital pores seen.

*Internal characters.* Muscular gizzard small in 7 and 8. No septa thickened, but the inner organs lacking except a small piece of the oesophagus bearing a paired, forward projecting calciferous glands in 9? The excretory system holoic avesculate. The intestine lacks typhlosolis.

*Remarks.* According to the original description, three acelitellate specimens were collected in Imeko, Ogun State, Nigeria. The holotype was deposited in NHM, London and the two paratypes ("syntype" in the original description) in the Natural History Museum, Olabisi Onabanjo University, Ago-Iwoye, Nigeria.

The holotype specimen is completely juvenile. According to the description, the last pair of hearths is in 11 which, in combination with the paired calciferous glands in 9? and two small gizzards in 7(?) and 8(?) place this specimen in the family Ocneroдрilidae and not Moniligastridae as in the original description. In appearance, the specimens has some similarity to a larger *Nematogenia lacuum* (Beddard, 1893) specimen but without developed genital characters it cannot be placed into any ocneroдрilid genus reliably.

#### Family Eudrilidae Claus, 1880

##### Pareudrilinae sp. juv.

*Paranematogenia eyinwaensis* Aladesida & Owa, 2015: 104. **nomen dubium**

*Material examined.* *Paranematogenia eyinwaensis* Aladesida & Owa, 2015 Syntype, NHM 2012.78-80 three juvenile specimens. Nigeria, Ogun state, Eyinwa. 12/7/2009. Leg. Adeyinka Aladesida.

<https://data.nhm.ac.uk/object/ca9d711e-52bf-42c5-9a65-39473b662253/1589414400000>

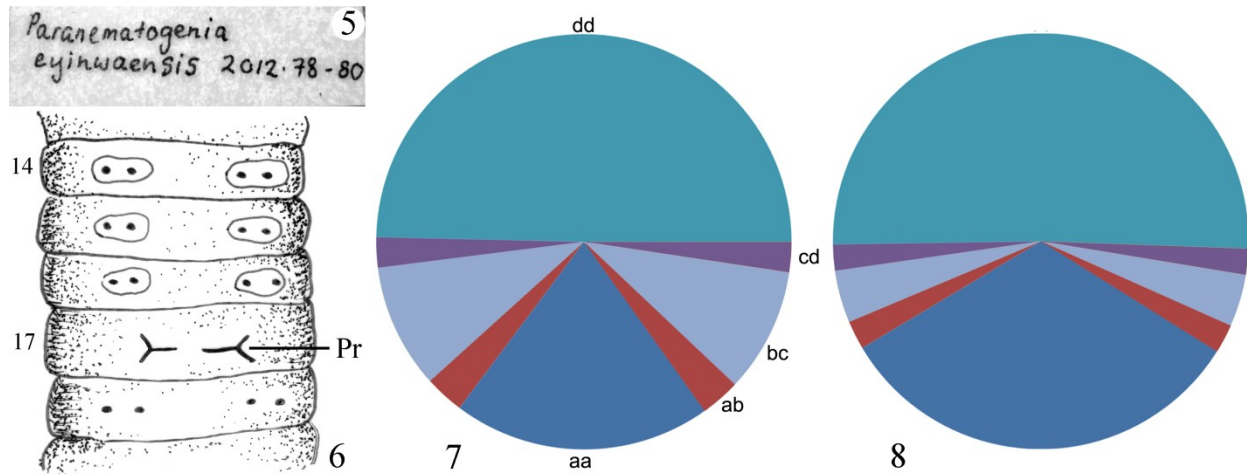
*Description.* Dimensions of the specimens: 105x2 mm, segment no. 221; 55x2 mm, segment no. 126, tail missing; 55x1.5 mm, segment no. 168. Colour pale. Head epilobous, dorsal pores lacking. Setae *ab* and *cd* closely paired, setal ratio  $aa:ab:bc:cd:dd = 8.8:1.3:4.1:1:21$ , after the prostatic pores the setal distance *aa* gradually became larger and *ab* smaller resulted in a very strange setal position with all the four setal line running laterally close to each other  $aa:ab:bc:cd:dd = 16:1.1:2:1:250$ . Nephridial pores aligned in setal line *d*. Clitellum not visible, the specimens completely juvenile, only the prostatic pores can be seen as paired, small, keeled Y-shaped slits be-

tween *a-a* in 17. Female pores and spermathecal pores not seen.

*Internal characters.* Muscular gizzard large in 5. Septa 6/7–8/9 slightly thickened. Calciferous glands lacking, but there is a calciferous gland like vascularization at the end of the oesophagus in 17–18. Last hearts possibly in 12, small moniliform. Testes and sperm funnels in 11. Vesicles one pair, long coiled tube running dorsally between 12–14. Ovo-spermathecal apparatus just poorly developed, an ovisac and the oviduct seen opening in the setal line *d* in 14. Prostates small euprostates in developing stage in 17 and the clearly seen male duct join the prostates at the neck. Developing penial setae present in 17 and also the setae in 14–16 developed as genital setae. Nephridial system holoic, vesiculate. Nephridial bladders simple sausage-shaped. Intestine begins abruptly in 20, typhlosolis present as shallow dorsal ridge.

*Remarks.* Under the heading Type material, the authors write that the „*The holotype has been repositied at the British Museum of Natural History, while the syntype is at the Museum of Natural History, Olabisi Onabanjo University, Ago-Iwoye, Nigeria*” However, in the Natural History Museum, London the vial registered under No. NHM2012.78-80 contains 3 specimens with locality Nigeria, Ogun state, Eyinwa. All the three specimens are juvenile but the smallest one lacks any sign of genital pores and also its setal arrangement is different from that of the two larger specimen. As in the original description there are three adult and one juvenile specimen here we designate the most grown broken specimen as lectotype with registration number NHM2012.78.

Unfortunately in the original description there are no dimension data and the specimen at hand differ completely from the original description; only the presence of a large oesophageal gizzard, the metandric male apparatus and the prostates in 17 fit. There are no calciferous glands in 9, but the oesophagus is slightly lobate between segments 8–10. A spermathecae in 8 completely lacking, might be it was mistaken for the well developed nephridial bladder.



Figures 5–7. *Paranematogenia eyinwaensis* Aladesida & Owa, 2015. 5 = vial label, 6 = clitellar region from ventral view, 7 = setal arrangement in segment 14, 8 = setal arrangement in segment 25. *Prp* = prostate pores.

The authors relegated their new genus to Ocnodrilidae, however the well-developed gizzard, the presence of euprostates with penial setae attached and furthermore the structure of the excretory system place this species to the subfamily Pareudrilinae of the family Eudrilidae. The structure of the hind end of the oesophagus is reminiscent of some West African *Stuhlmannia* Michaelsen, 1890 species which also show high vascularisation in the region of segment 16 (Sims 1987) however, they have single prostatic pore. The pareudriline genera with paired prostatic pores are *Nemertodrilus* Michaelsen, 1890 and *Pareudrilus* Beddard, 1894. *Nemertodrilus* is holandric and lacks penial setae but interestingly, *N. grieus* Michaelsen, 1890 possesses long tube-like vesicles in 12 running back to 18 similar as in *P. eyinwaensis*. Although, *Pareudrilus* possesses penial setae, it is holandric and has united female and spermathecal pores.

Unfortunately the juvenile stage of the ovospermathecal system prevents the exact identification of the specimens published under the name *Paranematogenia eyinwaensis*.

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## New records for the genus *Grammacephalus* Haupt (Hemiptera: Auchenorrhyncha: Cicadellidae)

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**Abstract.** *Grammacephalus rahmani* Singh Pruthi, 1930 is recorded for the first time from the United Arab Emirates and Mali, *G. raunoi* Viraktamath, 1981 – from the United Arab Emirates, and *G. indicus* Viraktamath et Ananta Murthy, 1999 – from Afghanistan. Photos of these species are provided, and male genitalia of *G. rahmani* and female 7<sup>th</sup> sternite of *G. indicus* are illustrated. Distribution and composition of the genus *Grammacephalus* Haupt is discussed.

**Keywords.** Deltocephalinae, Scaphoideini, morphology, new record, distribution, Middle East, Western Africa.

During my study of the leafhopper genus *Grammacephalus* Haupt, 1929 (Deltocephalinae, Scaphoideini) new records are registered for *G. rahmani* Singh Pruthi, 1930 from the United Arab Emirates and Mali, for *G. raunoi* Viraktamath, 1981 from the United Arab Emirates, and for *G. indicus* Viraktamath & Ananta Murthy, 1999 from Afghanistan.

According to the recently published revision of the genus *Grammacephalus* by Shah *et al.* (2019) it comprises 13 species distributed from India via Middle East to Africa including Cape Verde. However, Dlabola's (1980) record of *G. pugio* (Noualhier, 1895) (listed as *G. turneri* (Evans, 1947) a junior synonym of *G. pugio* according to Dlabola (1960)) from Saudi Arabia (Wadi Tihamma) was missed from this revision. According to my data the genus is also present in the United Arab Emirates, Mali, and Afghanistan. These new records are listed below.

### MATERIAL AND METHODS

The study based on the specimens deposited in the collection of the Zoological Institute of the

Russian Academy of Sciences, Saint Petersburg (Russia), collected between 1966 and 2010.

The photographs of the specimens were taken using the microscope Leica MZ9.5 and a Leica DFC 490 camera. Images were produced using Helicon Focus V. 6.7.1 and Adobe Photoshop software. The drawings were prepared using the same microscope with camera lucida attached.

### RESULTS AND DISCUSSION

#### *Grammacephalus indicus* Viraktamath & Anantha Murthy, 1999

(Figures 1, 2, 12, 17)

*Grammacephalus indicus* Viraktamath et Anantha Murthy, 1999: 42, figs 14–21.

*Material examined.* Afghanistan: 2♂, 1♀, Nangarkhar Province, Djalalabad, Kabul River, 22.VII.1966, E.S. Sugonyaev leg.

*Remarks.* The species was described from New Delhi in India (Viraktamath & Anantha Murthy 1999) and later recorded from Sindh and Punjab Provinces in Pakistan (Khatri & Webb 2010; Naveed & Zhang 2018).



**Figures 1–4.** *Grammacephalus* spp. 1 = *G. indicus*, male (Afghanistan), dorsal view; 2 = same, lateral view; 3 = *G. raunoi*, female (UAE), dorsal view; 4 = same, lateral view. Male – 4.5 mm. Female – 5.0 mm.

Male genitalia of the specimen from Afghanistan were examined and compared with the drawings by Viraktamath & Anantha Murthy (1999, figs 14–21) and Khatri & Webb (2010, figs 20, 21) and the photos by Naveed & Zhang (2018, fig. 1) with no significant differences discovered. From the other hand the hind margin of female 7<sup>th</sup> sternite illustrated by Khatri & Webb (2010, fig. 20c) is widely concave while the female from Djalalabad has it sharply notched medially (Fig. 12), wherein Viraktamath & Anantha Murthy (1999: 42) noticed in the original description of *G. indicus* that 7<sup>th</sup> sternite of this species has V-shaped excavation on its hind margin which is in accordance to the condition of the specimen from Afghanistan examined by the author (Fig. 12), confirmed also by the photo of female paratype of *G. indicus* kindly sent for my study by Dr. Chandrashekharaswamy A. Viraktamath (Bangalore, India). Thus Khatri & Webb (2010) apparently figured female 7<sup>th</sup> sternite of another species, different from *G. indicus*, erroneously reproduced again by Shah et al (2019, fig. 5D).

***Grammacephalus raunoi* Viraktamath, 1981**

(Figures 3, 4, 16)

*Grammacephalus raunoi* Viraktamath, 1981: 9, figs 30–36.

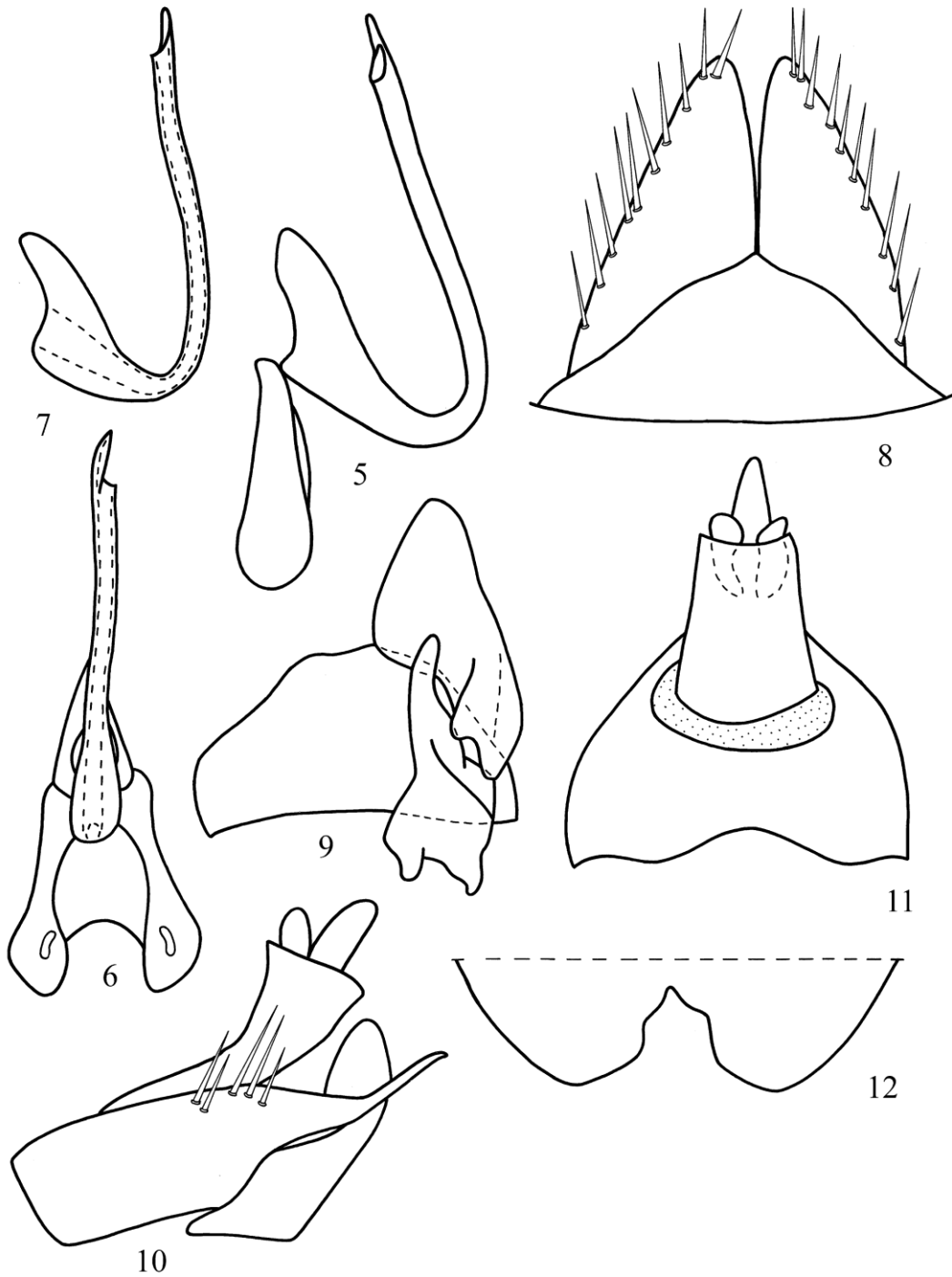
*Material examined.* United Arab Emirates: 1♂, 2♀, Sharjah, Sharjah Desert Park, N 25°16.859' E 55°41.422', 17.IV.2010, at light, V.M. Gnezdilov leg.

*Note.* The species was described from Delhi in India (Viraktamath 1981) and later recorded from Punjab (Mianwali) in Pakistan (Naveed & Zhang 2018). In UAE the species was collected in sand desert near to park house at light during the evening from 20.00 to 20.30.

***Grammacephalus rahmani* (Singh Pruthi, 1930)**

(Figures 5–11, 13–15)

*Platymetopius rahmani* Singh Pruthi, 1930: 33, figs 45, 46.



**Figures 5–12.** *Grammacephalus* spp. 5–11 = *G. rahmani*. 12 = *G. indicus* (Afghanistan). 5 = aedeagus and connective, lateral view (specimen from Mali); 6 = same, dorsal view; 7 = aedeagus, lateral view (here and following numbers – specimens from UAE); 8 = valve and subgenital plates, ventral view; 9 = valve, style, and subgenital plate, dorsal view; 10 = male pygofer, subgenital plate, and anal tube, lateral view; 11 = male pygofer and anal tube, dorsal view; 12 = female 7<sup>th</sup> sternite, ventral view.

*Material examined.* United Arab Emirates: 5♂, Sharjah, Sharjah Desert Park, N 25°16.859' E 55°41.422', 13.IV.2010, V.M. Gnezdilov leg. Mali: 1♂, Kita, 20.XII.1969, Orlovskaya leg.

*Remarks.* The species was described from Lyallpur (currently Faisalabad) in Punjab of Pakistan where it was collected at light (Singh Pruthi 1930). Later it was recorded from Sindh Province in Pakistan (Mahmood 1979, after Khatri & Webb 2010) and from India (Delhi, Gujarat, Jammu and Kashmir, Karnataka, Punjab) (Viraktamath 1981). In UAE the species was collected in sand desert during the day sweeping *Prosopis cineraria* (L.) Druce (Fabaceae).

Male genitalia of the species were illustrated by Singh Pruthi (1930, fig. 46) and later by Viraktamath (1981, figs. 2–8) based on the specimens from the Indian subcontinent. Viraktamath (1981: 8) suggested that *G. rahmani* could be conspecific with *G. turneri* (Evans, 1947), however, the latter is distinguished by sinuate aedeagal shaft and robust processes of pygofer. From the other hand Dlabola (1960: 17) and following him Shah *et al.* (2019: 81) treated *G. turneri* (Evans) as junior synonym of *G. pugio* (Noualhier) and separated it in the key by aedeagal shaft curved subapically in lateral view.

The specimens from UAE and Mali figured here (Figs 5–11) have aedeagal shaft slightly sinuate in dorsal view, but straight subapically in lateral view, and pygofer with slender processes. My examination of the photo of pygofer process and the aedeagus of *Platymetopius pugio* holotype described from Akbès (Alep) in Northern Syria (Puton & Noualhier 1895), deposited in the Museum national d' Histoire naturelle (Paris, France) and kindly sent for study by Dr. A. Soulier-Perkins, showed their identity with Linnavuori's figures (Linnavuori 1978, figs. 12f, 13a) reproduced by Shah *et al.* (2019). Apparently, for solving the question on possible synonymy of the mentioned names it will be necessary to examine the type specimen of *G. turneri* and compare it with *G. pugio* and *G. rahmani*. Currently, I am identifying the material from UAE and Mali as *G.*

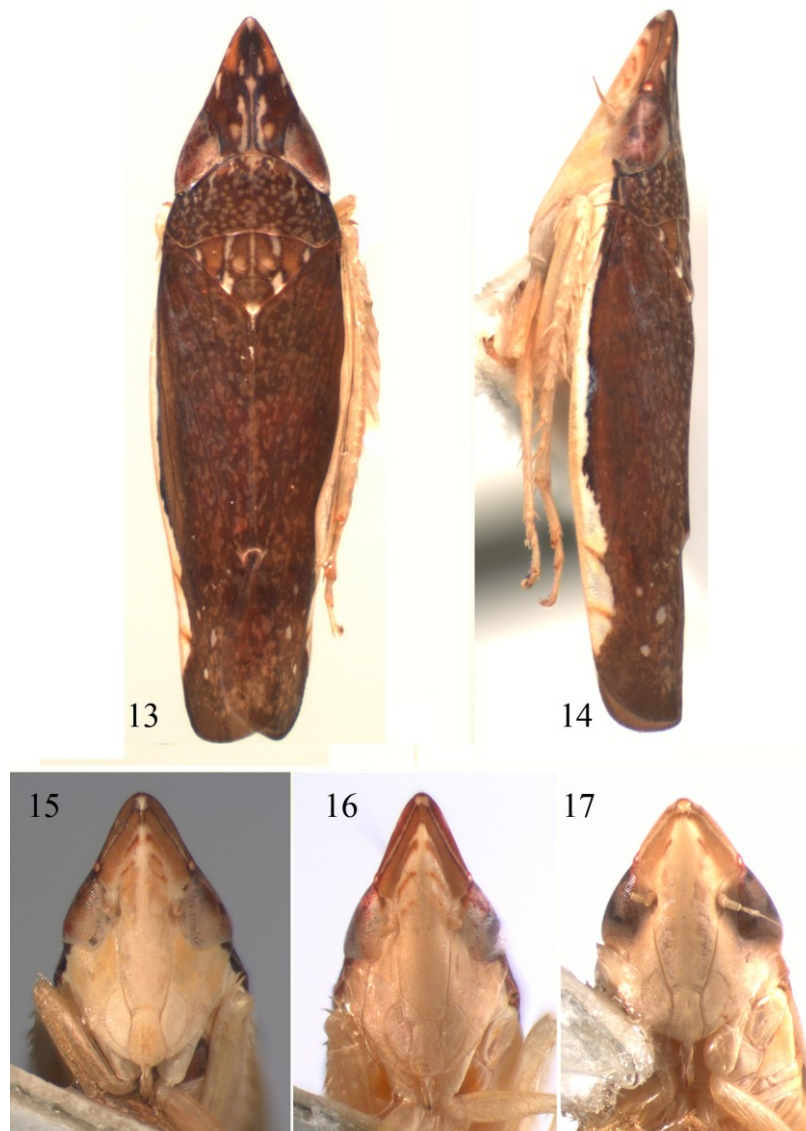
*rahmani* insofar as this species is well defined and illustrated.

## CONCLUSIONS

*Grammacephalus rahmani* together with *G. raunoi* are first records of the tribe Scaphoideini Oman, 1943 from the United Arab Emirates as herein the subfamily Deltocephalinae Dallas was known from UAE only after few species of the tribes Chiasmini Distant, Eupelicini Sahlberg, and Macrostelini Kirkaldy (Wilson & Turner 2010, Gnezdilov 2019).

Linnavuori (1978: 476) assumed that the genus *Grammacephalus* radiated from Africa to the Oriental region "...along the mountain ranges bordering the Red Sea...". However, according to current data within 13 described species of the genus 8–9 species are known from the Oriental region (7 – from Indian subcontinent, one – from southern China, and one unidentified species – from the Philippines (Webb & Godoy 1993)), 7 species – from Africa and Arabian Peninsula, and 3 species – from Iran. Probably *Grammacephalus* species have no particular host-plant specialization as different species are recorded from several plant families including Fabaceae, Rhamnaceae, and Sapindaceae (Viraktamath 1981; Dai *et al.* 2006, current data). Insofar as the species of *Grammacephalus* may easily fly for long distance we can not confidently locate the centre of diversification of this genus. Apparently, some species currently known as local endemics would be found later in other regions as it is demonstrated here for *G. rahmani* and *G. raunoi*.

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Figures 13–17. *Grammacephalus* spp. 13–15 = *G. rahmani*, male – 4.5 mm (UAE). 16 = *G. raunoi*, female (UAE). 17 = *G. indicus*, male (Afghanistan). 13 = dorsal view; 14 = lateral view; 15–17 = face.

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