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CHECKLIST

Earthworms (Annelida: Clitellata: Megadrili) of Solan, a constituent of Himalayan Biodiversity Hotspot, India

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Abstract

The present work is an update on the earthworm fauna of Solan District, Himachal Pradesh State, a constituent of Himalayan biodiversity hotspot. It is based on the field collection and published literature data. Hereby, it is provided an updated list of 32 species belonging to 18 genera and seven families, namely Moniligastridae, Lumbricidae, Ocnerodrilidae, Acanthodrilidae, Benhamiidae, Octochaetidae and Megascolecidae. These mainly include exotic and native peregrine species, including exotic peregrine *Amynthas hupeiensis* (Michaelsen, 1895), which was recently recorded for the first time from India. A systematic account of earthworm species with their distribution and a dichotomous key is provided for their identification.

Keywords

dichotomous key, distribution, endemic, exotic, native, taxonomy

Introduction

The exploration of earthworm fauna in the state Himachal Pradesh dates back to 1907, when Michaelsen described *Perionychella simlaensis* (=*Perionyx simlaensis*)

from Dharampur, Simla Hills (Shimla Hills). In 1914, Stephenson reported two species *Eisenia fetida* (Savigny, 1826) and *Octolasion lacteum* [=*Octolasion tyrtaeum* (Savigny, 1826)] from Himachal Pradesh. Subsequently, Stephenson (1915) described a new species, *Perionyx bainii,* from Sanjauli, Simla (Shimla) and also recorded *Pheretima heterochaeta* [=*Amynthas corticis* (Kinberg, 1867)] from the same region. The knowledge on earthworms of state was further enriched by Stephenson (1916, 1917, 1922, 1923); Černosvitov (1937); Soota and Halder (1980); Julka (1979,1981, 1988, 1999); Julka and Paliwal (1990, 1993, 1994, 2000, 2005a); Julka and Mukharjee (1984); Paliwal and Julka (2005, 2007, 2009). Paliwal (2008) reported 7 species from Pin Valley National Park. Subsequently, Paliwal (2009) reported 11 species from Simbalbara Wildlife Sanctuary. Recently, Kumari et al. (2017) and Ahmed and Julka (2017) recorded two exotic earthworm species *Dichogaster saliens* (Beddard, 1893) and *Amynthas hupeiensis* (Michaelsen, 1895) respectively, from Solan, Himachal Pradesh. Sharma et al. (2019) reported 10 species which belong to four families from mid hills of Himachal Pradesh.

Migration of earthworms mostly takes place through active and passive dispersal (Edwards and Bohlen 1996), but in active dispersal the deserts, mountains and oceans create effective physical barrier. The active dispersal in earthworm is very slow, estimated at about 5–10 meter / year (Addison 2009), whereas passive dispersion is common through anthropogenic activities and through transportation of cocoons in soil attached to feet of birds and animals (Gates 1972; Blakemore 2002; Brown et al. 2006; Julka 2014). Passive dispersal contributes majorly toward the spread of earthworm species far away from their home range (Brown et al. 2006). Species which are successfully established outside their native ranges are called peregrine (Michaelsen 1903). These peregrine species are generally found in disturbed habitats, near to human settlements (Brown et al. 2006). More than 100 such species which are considered peregrine (Blakemore 2002) are present globally. In India, their number is estimated to be 53, representing about 12.1% of the country's earthworm diversity (Julka 2014; Ahmed and Julka 2017; Kharkongor 2018; Narayanan et al. 2019a). On the basis of endemicity and dispersal, Indian earthworms are categorized into: i) endemic or native species, which are restricted to India; ii) exotic peregrine species, which originated in other biogeographical regions; iii) native peregrine species, which evolved in India and now gained widespread distribution in the country and also in other biogeographical regions (Julka and Paliwal 2005b; Narayanan et al. 2016a).

The present paper aims to update the existing knowledge on earthworm communities of Solan District, a constituent of the Himalayan biodiversity hotspot, which is facing problems of fast deteriorating ecology and impacts of climate change. The studies are also hampered in the absence of simple ready to use regional keys for the identification of earthworms. Therefore, a simple dichotomous key primarily based on the easily recognizable character for the identification of earthworm species for the use of non-specialists is also provided.

Material and methods

Study area

Present study was conducted in Solan (Fig. 1) district of Himachal Pradesh, situated between 30.834° to 31.250° N and 76.700° to 77.333° E. The total geographical area of the district is about 1,936 km^2 which constitutes about 3.49 % of the total area of the state. Altitude of district ranges from 300–3,000m a.s.l. The climate varies between subtropical to sub temperate depending on elevation. Four distinct seasons are recognised: i) spring (late February to April), ii) summer (May to middle of September), iii) autumn (middle of September to middle of November) and iv) winter (middle of November to middle of February). An average annual rainfall of 1420.4 mm is received mostly during the monsoons, from July to mid-September. The precipitation in winter (December – January) is in the form of heavy snow at high altitudes and moderate rain in the mid and foot hills. The month of January is the coldest with an average temperature of 0.6°C and May is the warmest month with an average temperature of 32.2°C (Anonymous 2013).

Earthworm sampling

Earthworms were collected by digging and hand sorting method from different land use systems following the standard technique as described by Anderson and Ingram (1993). Collected worms were washed with water before preserving in 5% formalin. Each sample was labeled indicating locality and date of collection. The preserved specimens were identified following the monographs by Gates (1959, 1972); Julka (1988) and Blakemore (2007a, 2012). For validation, species names and higher classification, the works of Csuzdi (2012) and Csuzdi et al. (2018) are followed. After identification, all specimens are stored in the laboratory of Zoology in Shoolini University, Solan, Himachal Pradesh, India.

Results

Altogether the published literature and fresh collection reveals the presence of 32 species belonging to seven families namely, Moniligastridae, Lumbricidae, Ocnerodrilidae, Acanthodrilidae, Benhamiidae, Octochaetidae and Megascolecidae in Solan District (Paliwal and Julka 2005; Kumari et al. 2017; Ahmed and Julka 2017). Among the recorded families, Megascolecidae is the most diverse family with 13 species, and the largest genera having maximum species are *Amynthas* and *Perionyx,* each with four species in the study site. Further range expansion of the species *Lampito mauritii* Kinberg, 1867, *Eutyphoeus waltoni* Michaelsen, 1907 and *Metaphire posthuma* (Vaillant, 1868) are observed during the present study, as *Lampito mauritii* is recorded first time from Western Himalaya, whereas *Metaphire posthuma* and *Eutyphoeus waltoni* are recorded first time from the study sites. Among the recorded species, 19 are exotic peregrine, 10 native peregrine and

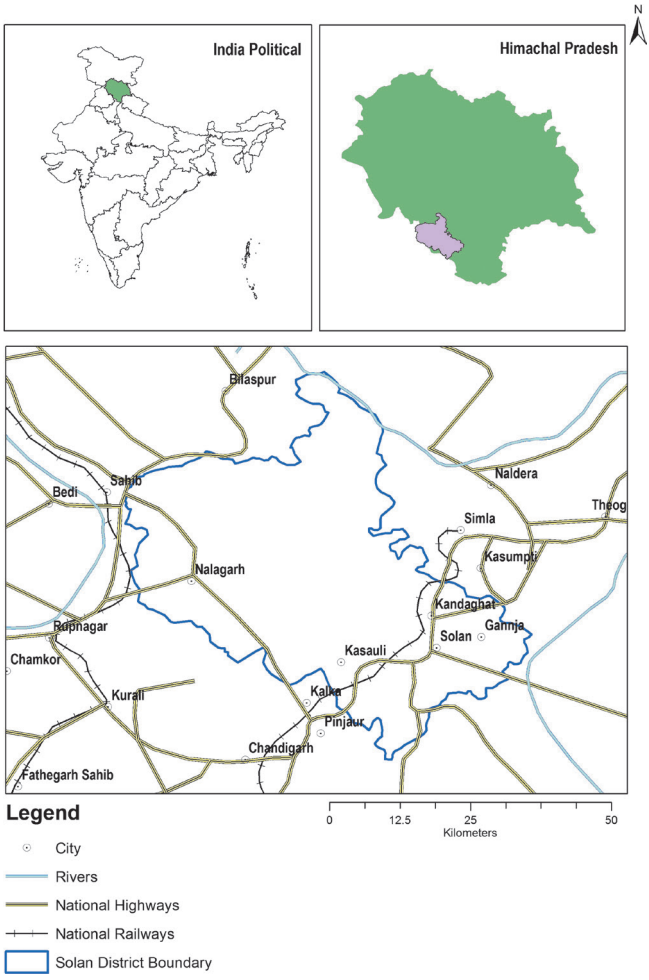

Figure 1. Map of Solan District, Himachal Pradesh, India.

three endemic or near endemic to the study site. The detailed distribution of the earthworm species of district Solan has been plotted in Figures 2 and 3. A running key is provided for their identification. In the present study for earthworm species distribution mainly the works of Julka (1988); Paliwal and Julka (2005); Joshi et al. (2010); Narayanan et al. (2016a, 2016b, 2019b); Kumari et al. (2017); Ahmed and Julka (2017); Goswami (2018); Ahmed and Gupta (2019) for India, and Gates (1972); Julka (1988); Csuzdi and Pavliček (2009); Blakemore (2007b, 2012, 2013, 2014, 2016); Valchovski (2014); Mısırlıoğlu et al. (2019) for the distribution outside the country are followed. Further, the habitat of the species reported in the present study is based on the present collection and published literature.

Systematic account

The taxa marked with asterisk (*) are recorded from literature.

Phylum Annelida
Class Clitellata
Order Moniligastrida
Family Moniligastridae
Genus *Drawida* Michaelsen, 1900

1. *Drawida japonica* (Michaelsen, 1892)

Moniligaster japonicus Michaelsen 1892: 232.
Drawida japonica: Michaelsen (1900: 115); Kobayshi (1938: 94); Gates (1939a: 411).
Material examined: 2 clitellates, 3 aclitellates, locality name Chail, alt. 1799 m, date of collection 11-12-2013, coll. Shakoor Ahmed.
Distribution. India: Himachal Pradesh (Solan: Arki, Barog, Chail, Deothal, Dharampur, Gambhar Bridge, Sadhupul, Shilli Forest, Solan and Subathu), Jammu and Kashmir, Uttarakhand. Elsewhere: China, Japan, Korea, Pakistan, South-east Asia and Taiwan.
Ecological group. Endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, cultivation, orchard, plantation.

2. *Drawida nepalensis* Michaelsen, 1907

Drawida nepalensis Michaelsen 1907: 146.
Drawida burchardi: Michaelsen (1909: 149).
Drawida troglodytes: Stephenson (1924: 129).
Drawida hodgarti: Stephenson (1925: 51).
Drawida papillifer (in part): Stephenson (1925: 51).
Drawida cacharensis: Stephenson (1926: 251).
Drawida nepalensis: Gates (1972: 256).
Material examined: 9 clitellates, 5 aclitellates, locality name Shilli Village, alt. 1454 m, date of collection 15-07-2014, coll. Shakoor Ahmed.
Distribution.India: Andaman and Nicobar Island, Arunachal Pradesh, Assam, Bihar, Haryana, Himachal Pradesh (Solan: Shilli village), Jammu and Kashmir, Karnataka, Punjab, Meghalaya, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Bangladesh, China, Indonesia, Myanmar, Nepal and Pakistan.
Ecological group. Endogeic.
Zoogeographical distribution type. Native peregrine.
Habitat. Forest, crop filed, orchard, home garden and rubber plantation.

Order Opisthophora
Family Lumbricidae
Genus *Aporrectodea* Örley, 1885

3. *Aporrectodea caliginosa caliginosa* (Savigny, 1826)

Enterion caliginosum Savigny 1826: 180.
Allolobophora tuberculata: Gates (1972: 79).
Allolobophora turgida: Gates (1972: 89).
Allolobophora caliginosa caliginosa: Zicsi (1982: 425); Easton (1983: 476).
Material examined: 89 clitellates, 45 aclitellates, locality name Chail, alt. 1799 m, date of collection 13-10-2013, coll. Shakoor Ahmed.
Distribution. India: Himachal Pradesh (Solan: Blossom, Chail, Nagali and Shilli), Jammu and Kashmir. Elsewhere: Africa, Argentina, Australia, Brazil, Chile, China, Colombia, Ecuador, Egypt, Europe, Hawaii, Iran, Israel, Japan, Mexico, New Zealand, Pakistan, Palestine, Paraguay, Qatar and Turkey.
Ecological group. Endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, cultivation, orchard, home garden.

4*. *Aporrectodea caliginosa trapezoides* (Dugès, 1828)

Lumbricus trapezoides Dugès 1828: 289.
Lumbricus capensis: Kinberg (1867: 100).
Allolobophora trapezoides: Gates (1958: 2); Gates (1972: 76).
Aporrectodea caliginosa trapezoides: Easton (1983: 477).
Distribution. India: Himachal Pradesh (Solan: Blossom, Chail, Gambhar Bridge, Jabli, Junga, Sadhupul and Solan), Jammu and Kashmir, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh. Elsewhere: Afghanistan, Africa, Australia, China, England, Europe, Hawaii, Iran, Japan, Korea, Mexico, New Zealand, North and South Africa, North and South America, Pakistan, Tasmania and Turkey.
Ecological group. Endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, vegetable field, stream bank, *Populus* plantation.

5. *Aporrectodea rosea rosea* (Savigny, 1826)

Enterion roseum Savigny 1826: 182.
Allolobophora mucosa: Eisen (1874: 47).
Eisenia rosea: Michaelsen (1900: 478); Gates (1972: 104).
Allolobophora harbinensis Kobayashi (1940: 290).
Allolobophora rosea rosea: Zicsi (1982: 437).
Aporrectodea rosea rosea: Easton (1983: 477).

Material examined: 17 clitellates, 7 aclitellates, locality name Chail, alt. 1800 m, date of collection 17-09-2015, coll. Shakoor Ahmed.
Distribution. India: Himachal Pradesh (Solan: Chail, Dagshai, Dharampur, Jabli, Jhajha, Kasauli, Nagali, Sadhupul, Shilli and Solan), Gujarat, Jammu and Kashmir, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Australia, China, Europe, Japan, Middle East, Central and South America, North Africa, New Zealand, Siberia, Tasmania and Turkey.
Ecological group. Endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, cultivation, orchard, pasture.

Genus *Bimastos* Moore, 1893

6. *Bimastos parvus* (Eisen, 1874)

Allolobophora parva Eisen 1874: 46.
Eisenia udei: Michaelsen (1900: 477).
Allolobophora (*Bimastos*) *parva*: Stephenson (1923: 506).
Bimastus parvus: Gates (1930: 352).
Bimastos parvus: Gates (1972: 87).
Material examined: 3 clitellates, 1 aclitellate, locality name Shilli Village, alt. 1463 m, date of collection 17-02-2014, coll. Shakoor Ahmed.
Distribution. India: Bihar, Jammu and Kashmir, Himachal Pradesh (Solan: Arki, Ashwini Khud, Barog, Chail, Jarash, Kasauli, Nalagarh, Oachghat, Ramshahar, Shilli Forest, Solan and Swargdwari), Punjab, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Afghanistan, Argentina, Australia, Brazil, Great Britain, Canada, North, Central and South America, China, Costa Rica, England, Europe, Guatemala, Hawaii, Iceland, Ireland, Japan, Java, Kazakhstan, Korea, Malaysia, Mexico, Myanmar, New Zealand, Pakistan, Russia, South Africa, Taiwan, Tibet, Venezuela and Vietnam.
Ecological group. Epigeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, vegetable filed, garden, manure, under logs.

Genus *Eisenia*Malm, 1877

7. *Eisenia fetida* (Savigny, 1826)

Enterion fetidum Savigny 1826: 182.
Eisenia foetida: Michaelsen (1900: 475); Zicsi (1982: 428).
Eisenia fetida: Easton (1983: 480).
Material examined: 4 clitellates, 6 aclitellates, locality name Shilli village, alt. 1463m, date of collection 13-09-2015, coll. Shakoor Ahmed.

Distribution. India: Andaman and Nicobar Island, Assam, Chandigarh, Delhi, Himachal Pradesh (Solan: Arki, Chail, Kasauli, Oachghat, Shilli forest and Solan), Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Argentina, Australia, Brazil, Cambodia, Canary Islands, China, Chile, Colombia, Carpathian Basin, Ecuador, Greenland, Hawaii, Israel, Japan, Jordan, Korea, Mexico, New Zealand, Russia, South Africa, Turkestan and Turkey.
Ecological group. Epigeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, cultivation, grassland, plantation.

Genus *Eiseniella* Michaelsen, 1900

8*. *Eiseniella tetraedra tetraedra* (Savigny, 1826)

Enterion tetraedrum Savigny 1826: 184.
Eiseniella tetraedra (in part): Michaelsen (1900: 471); (f. typica) Černosvitov (1937: 107); Gates (1972: 108).
Eiseniella intermedius: Jackson (1931: 123).
Eiseniella tetraedra tetraedra: Easton (1983: 481); Blakemore (2012: 723).
Distribution. India: Himachal Pradesh (Solan: Ashwini Khud, Chail Sanctuary, Oachghat and Sadhupul), Karnataka, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Afghanistan, Algeria, Argentina, Australia, Balkans, Brazil, Bolivia, California, Canada, Carpathian Basin, Chile, Colombia, Colorado, Ecuador, Illinois, Indiana, Iran, Israel, Japan, Libya, Mexico, Michigan, New Zealand, Ohio, Pennsylvania, Peru, South Africa, Syria, Taiwan, Tajikistan, Tasmania, Turkestan, Turkey and Venezuela.
Ecological group. Epigeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, cultivation, pasture, manure heap.

Genus *Octolasion* Örley, 1885

9. *Octolasion tyrtaeum* (Savigny, 1826)

Enterion tyrtaeum Savigny 1826: 180.
Lumbricus tyrtaeus: Duges (1837: 17); Michaelsen (1900: 513).
Lumbricus terrestris lacteus: Orley (1881: 584).
Lumbricus gracile: Orley (1885: 18).
Octolasion tyrtaeum: Gates (1972: 125); Easton (1983: 483); Christopherson (2011: 161); Blakemore (2012: 777).
Octolasion lacteum: Zicsi (1982: 432).

Material examined: 4 clitellates, 14 aclitellates, locality name Chail, alt. 1800 m, date of collection 17-03-2015, coll. Shakoor Ahmed.
Distribution. India: Himachal Pradesh (Solan: Blossom, Chail, Hinner, Jhajha, Kasauli, Nagali, Shilli village and Solan), Jammu and Kashmir, Karnataka, Kerala, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Algeria, Argentina, Australia, Canada, China, France, Iran, Kazakhstan, Latvia, Lithuania, Mexico, Moldova, New Zealand, Pakistan, Portugal, Russia, Siberia, South Africa, Spain, Turkestan, Ukraine and Uruguay.
Ecological group. Endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, cultivation, orchard.

Family Ocnerodrilidae
Genus *Ocnerodrilus* Eisen, 1878

10*. *Ocnerodrilus occidentalis* Eisen, 1878

Ocnerodrilus occidentalis Eisen 1878: 10.
Ocnerodrilus tenellulus: Gates (1945: 223).
Ocnerodrilus occidentalis: Gates (1972: 14); Julka and Senapatti (1987: 18); Blakemore (2012: 195); Narayanan et al. (2016a: 124).
Distribution. India: Andaman and Nicobar Island, Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh (Solan: Nalagarh and Solan), Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Uttarakhand, Uttar Pradesh. Elsewhere: Australia, Cape Verde Islands, China, Cuba, Denmark, Germany, Greece, Israel, Italy, Japan, Jordan, Korea, Lebanon, Mexico, Mozambique, Myanmar, Pakistan, Philippines, Singapore, Solomon Island, Spain, Sri Lanka, United States, Vanuatu and Zimbabwe.
Ecological group. Endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Grassland, cultivation, sewage, fallow land.

Family Acanthodrilidae
Genus *Microscolex* Rosa, 1887

11*. *Microscolex phosphoreus* (Dugès, 1837)

Lumbricus phosphoreus Dugès 1837: 17, 24.
Microscolex modestus: Rosa (1887: 1).
Microscolex benhami: Michaelsen (1900: 141).
Microscolex phosphoreus: Stephenson (1914: 388); Gates (1972: 35); Blakemore (2012: 219).

Distribution. India: Himachal Pradesh (Solan: Dedgharat and Kailar). Elsewhere: Africa, Algeria, Australia, Europe, Ireland, Israel, Japan, New Zealand, Pakistan, South America and Turkey.
Ecological group. Epi-endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Orchard.

Family Benhamiidae
Genus *Dichogaster* Beddard, 1888

12*. *Dichogaster bolaui* (Michaelsen, 1891)

Benhamia bolavi Michaelsen 1891: 9.
Dichogaster malayana: Horst (1893: 35); Stephenson (1923: 475).
Benhamia rugosa: Eisen (1896: 136).
Dichogaster bolaui: Michaelsen (1900: 340); Gates (1972: 279); Julka (1988: 103); Blakemore (2012: 245).
Distribution. India: Andaman and Nicobar Island, Andhra Pradesh, Arunachal Pradesh, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh (Solan: Deli), Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, Uttarakhand, Tripura, West Bengal. Elsewhere: Africa, Argentina, Australia, Bangladesh, Belize, Brazil, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Haiti, Honduras, Indonesia, Jamaica, Japan, Malay Peninsula, Mexico, Myanmar, Netherland, New Zealand, Pakistan, Panama, Paraguay, Philippines, Sri Lanka, Venezuela and Vietnam.
Ecological group. Epigeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, cultivation, plantation, mango orchard, fallow land, sewage.

13*. *Dichogaster saliens* (Beddard, 1893)

Microdrilus saliens Beddard 1893: 683.
Dichogaster saliens: Eisen (1900: 226); Gates (1972: 481); Julka (1988: 113); Blakemore (2012: 251).
Dichogaster crawi: Eisen (1900: 228).
Distribution. India: Andaman and Nicobar Island, Arunachal Pradesh, Assam, Himachal Pradesh (Solan: Bajhol), Karnataka, Meghalaya, Sikkim, West Bengal. Elsewhere: Argentina, Australia, Bolivia, Brazil, Cuba, Ecuador, Europe, Indonesia, Madagascar, Malaysia, Mexico, Peru, Singapore, Taiwan, Vietnam, United States and Venezuela.
Ecological group. Endogeic.
Zoogeographical distribution type. Exotic peregrine.

Habitat. Forest, garden, stream bank.

Family Octochaetidae
Genus *Eutyphoeus* Michaelsen, 1900

14*. *Eutyphoeus incommodus* (Beddard, 1901)

Typhoeus incommodus Beddard 1901: 200.
Eutyphoeus mohammedi: Stephenson (1914: 350).
Eutyphoeus incommodus: Michaelsen (1903: 109); Gates (1938: 83); Julka (1988: 145).
Distribution. India: Arunachal Pradesh, Bihar, Chandigarh, Haryana, Himachal Pradesh (Solan: Kasauli), Jammu and Kashmir, Jharkhand, Madhya Pradesh, Odisha, Punjab, Rajasthan, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Pakistan.
Ecological group. Endogeic.
Zoogeographical distribution type. Native peregrine.
Habitat. Forest, cultivation, grass land, orchard, plant nurseries.

15. *Eutyphoeus waltoni* Michaelsen, 1907

Eutyphoeus waltoni (in part) Michaelsen 1907: 179.
Eutyphoeus bengalensis: Michaelsen (1907: 183).
Eutyphoeus ibrahimi: Stephenson (1923: 438).
Eutyphoeus waltoni: Julka (1988: 174).
Material examined: 2 clitellates, locality name Shilli, alt. 1463m, date of collection 10-05-2015, coll. Shakoor Ahmed.
Distribution. India: Bihar, Chandigarh, Delhi, Gujarat, Himachal Pradesh (Solan: Solan and Nalagarh), Jammu and Kashmir, Madhya Pradesh, Manipur, Punjab, Rajasthan, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Pakistan.
Ecological group. Anecic.
Zoogeographical distribution type. Native peregrine.
Habitat. Forest, cultivation, orchard, grassland, home garden, leaf litter, plant nurseries manure heap.

Genus *Lennogaster* Gates, 1939

16. *Lennogaster chittagongensis* (Stephenson, 1917)

Eudichogaster chittagongensis Stephenson 1917: 411.
Lennogaster chittagongensis: Gates (1939b: 192); Gates (1972: 306); Julka (1988: 245).

Material examined: 4 clitellates, locality name Shilli, alt. 1463 m, date of collection 17-08-2014, coll. Shakoor Ahmed.
Distribution. India: Chandigarh, Himachal Pradesh (Solan: Dharampur, Gaura, Kunihar, Malon, Oachghat, Sadhupuland Shilli village), Jammu and Kashmir, Rajasthan, Tripura, West Bengal. Elsewhere: Bangladesh and Myanmar.
Ecological group. Endogeic.
Zoogeographical distribution type. Native peregrine.
Habitat. Forest, orchard, rubber plantation, grass land.

17. *Lennogaster pusillus* (Stephenson, 1920)

Eudichogaster pusillus Stephenson 1920: 253.
Eudichogaster barkudensis: Stephenson (1923: 408).
Lennogaster barkudensis: Gates (1939b: 191).
Lennogaster pusillus: Gates (1939b: 199); Julka (1988: 252).
Material examined: 11 clitellates, locality name Shilli, alt. 1463m, date of collection 17-08-2014, coll. Shakoor Ahmed.
Distribution. India: Chandigarh, Haryana, Himachal Pradesh (Solan: Solan and Shilli forest), Jammu and Kashmir, Jharkhand, Karnataka, Madhya Pradesh, Manipur, Odisha, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Indonesia.
Ecological group. Endogeic.
Zoogeographical distribution type. Native peregrine.
Habitat. Forest, cultivation, orchard, grassland, leaf litter, under growing ferns on the rock, middens, compost pits.

Genus *Octochaetona* Gates, 1962

18. *Octochaetona beatrix* (Beddard, 1902)

Octochaetus beatrix Beddard 1902: 456.
Octochaetus hodgarti: Michaelsen (1907: 172).
Octochaetus dasi: Stephenson (1914: 346).
Octochaetus (*Octochaetoides*) *fermori*: Stephenson (1923: 378).
Octochaetona beatrix: Gates (1962: 213); Gates (1972: 308); Julka (1988: 271); Narayanan et al. (2016b: 39).
Material examined: 2 clitellates, locality name Shilli, alt. 1463 m, date of collection 15-07-2014, coll. Shakoor Ahmed.
Distribution. India: Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chandigarh, Goa, Gujarat, Himachal Pradesh (Solan: Kasauli, Kunihar, Nalagarh, Oachghat, Sadhupul, Shilli and Subathu), Haryana, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand, West Bengal. Elsewhere: Australia, Malaysia, Myanmar, Nepal, Philippines, Pakistan and Vietnam.

Ecological group. Endogeic.
Zoogeographical distribution type. Native peregrine.
Habitat. Forest, cultivation, orchard, grassland, rubber plantation, flower pots.

Genus *Ramiella* Stephenson, 1921

19*. *Ramiella bishambari* (Stephenson, 1914)

Octochoetus bishambari Stephenson 1914: 347.
Octochaetus pachpaharensis: Stephenson (1920: 239).
Ramiella bishambari: Stephenson (1921: 109); Stephenson (1923: 398); Julka (1988: 317).
Distribution. India: Andaman and Nicobar Island, Andhra Pradesh, Chandigarh, Himachal Pradesh (Solan: Kunihar), Karnataka, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: China, Christmas Island, Myanmar, Pakistan, Philippines and Vietnam.
Ecological group. Endogeic.
Zoogeographical distribution type. Native peregrine.
Habitat. Forest, cultivation, grassland, stream and ponds bank.

Family Megascolecidae
Genus *Amynthas* Kinberg, 1867

20. *Amynthas corticis* (Kinberg, 1867)

Perichaeta corticis Kinberg 1867: 102.
Pheretima mirabilis: Michaelsen (1900: 284).
Pheretima diffringens: Gates (1972: 177).
Amynthas corticus: Easton (1981: 49); Easton (1982: 726); Blakemore (2012: 344); Narayanan et al. (2016b: 40).
Material examined: 5 clitellates, 6 aclitellates, locality name Shilli, alt. 1463 m, date of collection 10-12-2014, coll. Shakoor Ahmed.
Distribution. India: Arunachal Pradesh, Assam, Himachal Pradesh (Solan: Arki, Bajhol, Barog, Chail, Deothal, Dharampur, Gambhar Bridge, Kasauli, Koti, Kuthar, Malon, Nagali, Nalagarh, Parwanu, Sadhupul, Shilli Forest, Solan and Subathu), Jammu and Kashmir, Karnataka, Kerala, Manipur, Meghalaya, Mizoram, Punjab, Sikkim, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Argentina, Australia, Bangladesh, Bhutan, Bolivia, Brazil, China, Colombia, Cuba, Dominican Republic, Ecuador, El Salvador, France, Guatemala, Indonesia, Jamaica, Japan, Korea, Madagascar, Mexico, Myanmar, Nepal, New Zealand, Pakistan, Panama, Papua New Guinea, Peru, South Africa, Taiwan, Turkey, United Kingdom and Venezuela.
Ecological group. Epi-endogeic.

Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, cultivation, orchard, stream bank, oak plantation.

21. *Amynthas gracilis* (Kinberg, 1867)

Nitocris gracilis Kinberg 1867: 102.
Perichaeta hawayana: Rosa (1891: 396).
Perichaeta bermudensis: Beddard (1892: 160).
Nitocris gracilis: Michaelsen (1900: 419).
Pheretima hawayana: Gates (1972: 189).
Amynthas gracilis: Easton (1981: 50); Blakemore (2012: 361).
Material examined: 4 clitellates, locality name Chail, alt. 1800m, date of collection 17-12-2013, coll. Shakoor Ahmed.
Distribution. India: Himachal Pradesh (Solan: Chail, Shilli and Nalagarh), Punjab, Uttarakhand. Elsewhere: Argentina, Australia, Bangladesh, Barbados, Bermuda, Brazil, Chile, China, Colombia, Cuba, Egypt, El Salvador, France, French Guiana, Guatemala, Japan, Korea, Malaysia, Mexico, Myanmar, New Zealand, Pakistan, Poland, Russia, Singapore, Sri Lanka, Thailand, Taiwan, Turkey, United Kingdom, United States, Uruguay and Venezuela.
Ecological group. Epi-endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Cultivation, orchard.

22. *Amynthas hupeiensis* (Michaelsen, 1895)

Perichaeta hupeiensis Michaelsen 1895: 35.
Amyntas hupeiensis: Michaelsen (1899: 6).
Pheretima hupeiensis: Michaelsen (1900: 273).
Amynthas hupeiensis: Sims and Easton (1972: 237); Blakemore (2012: 367).
Material examined: 1 clitellate, 1 aclitellate, locality name Chail, alt. 1800 m, date of collection 13-04-2015, coll. Shakoor Ahmed.
Distribution. India: Himachal Pradesh (Solan: Chail). Elsewhere: Australia, China, Japan, Korea, New Zealand, North America, Taiwan and Vietnam.
Ecological group. Epi-endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Orchard.

23. *Amynthas morrisi* (Beddard, 1892)

Perichaeta morrisi Beddard 1892: 166.
Amynthas barbadensis: Michaelsen (1900: 254).
Pheretima morrisi: Gates (1937: 205).
Amynthas morrisi: Sims and Easton (1972: 236); Blakemore (2012: 388).

Material examined: 4 clitellates, 2 aclitellates, locality name Chail, alt. 1800 m, date of collection 17-12-2013, coll. Shakoor Ahmed.
Distribution. India: Chandigarh, Delhi, Haryana, Himachal Pradesh (Solan: Chail, Deothal, Dharampur, Sadhupul, Shilli, Solan and Subathu), Jammu and Kashmir, Maharashtra, Manipur, Meghalaya, Mizoram, Punjab, Rajasthan, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Australia, China, Hong Kong, Indonesia, Italy, Malaysia, Mexico, Myanmar, Pakistan, Singapore, South Africa, Spain, Taiwan, Thailand, Turkey, United Kingdom, United States and Vietnam.
Ecological group. Epi-endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, oak plantation, cultivation, orchard, stream bank.

Genus *Lampito* Kinberg, 1867

24. *Lampito mauritii* Kinberg, 1867

Lampito mauritii Kinberg 1867: 103.
Megascolex armatus: Rosa (1888: 159).
Megascolex mauritii: Stephenson (1923: 259).
Lampito mauritii: Soota and Julka (1970: 202); Gates (1972: 133).
Material examined: 2 clitellates, 4 aclitellates, locality name Nalagarh, alt. 372m, date of collection 12-09-2015, coll. Shakoor Ahmed.
Distribution. India: Andaman and Nicobar Island, Andhra Pradesh, Assam, Bihar, Delhi, Himachal Pradesh (Solan: Nalagarh), Gujarat, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Pondicherry, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand, West Bengal. Elsewhere: Australia, Bangladesh, Cambodia, China, Hong Kong, Indonesia, Laos, Madagascar, Maldives, Malaysia, Mauritius, Myanmar, New Caledonia, Pakistan, Philippines, Seychelles, Singapore, Sri Lanka, Thailand, Tanzania, United States and Vietnam.
Ecological group. Endogeic.
Zoogeographical distribution type. Native peregrine.
Habitat. Forest, cultivation, grassland, orchard, banana and coconut plantation, compost pit, sewage.

Genus *Metaphire* Sims & Easton, 1972

25. *Metaphire birmanica* (Rosa, 1888)

Perichaeta birmanica Rosa 1888: 164.
Amyntas birmanicus: Beddard (1900: 637).
Pheretima birmanica: Stephenson (1923: 295); Gates (1972: 172).
Metaphire birmanica: Sims and Easton (1972: 238); Blakemore (2012: 430).

Material examined: 4 clitellates, locality name Shilli, alt. 1463 m, date of collection 17-08-2014,coll. Shakoor Ahmed.
Distribution. India: Haryana, Himachal Pradesh (Solan: Shilli village), Meghalaya, Uttarakhand, Uttar Pradesh. Elsewhere: China, Laos, Myanmar, Pakistan, Thailand and Vietnam.
Ecological group. Endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, cultivation, orchard, agroforestry.

26. *Metaphire houlleti* (Perrier, 1872)

Perichaeta houlleti Perrier 1872: 99.
Perichaeta campanulata: Rosa (1890: 115).
Perichaeta travancorensis: Fedarb (1898: 435).
Amyntas kelantanensis: Beddard (1900: 902).
Pheretima crescentica: Michaelsen (1900: 273).
Pheretima houlleti (in part): Stephenson (1923: 313).
Pheretima campanulata var. *penetralis*: Gates (1931: 435).
Pheretima campanulata var. *meridiana*: Gates (1932: 457).
Metaphire houlleti: Sims and Easton (1972: 238); Blakemore (2012: 478).
Material examined: 1 clitellate, 1 aclitellate, locality name Shilli, alt. 1463 m, date of collection 11-09-2015, coll. Shakoor Ahmed.
Distribution. India: Andaman and Nicobar Island, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh (Solan: Chhawasa, Dharampur, Kasauli, Gaura, Gambhar Bridge, Nalagarh, Oachghat, Solan and Shilli village), Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Odisha, Punjab, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand, West Bengal. Elsewhere: Australia, Bahamas, Cambodia, China, Cuba, El Salvador, Fiji, France, French Guiana, Guadeloupe, Indonesia, Laos, Madagascar, Malaysia, Mexico, Myanmar, Nepal, Papua New Guinea, Philippines, Sierra Leone, Singapore, Sri Lanka, Taiwan, Thailand and Vietnam.
Ecological group. Epi-endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Cultivation, orchard, grassland, coconut and rubber plantation, and manure heap.

27. *Metaphire posthuma* (Vaillant, 1868)

Perichaeta posthuma Vaillant 1868: 228.
Perichaeta affinis: Perrier (1872: 106).
Pheretima posthuma: Michaelsen (1900: 295); Stephenson (1923: 309); Gates (1972: 212).
Metaphire posthuma: Sims and Easton (1972: 239); Blakemore (2012: 499).

Material examined: 5 clitellates, 16 aclitellates, locality name Nalagarh, alt. 372 m, date of collection 15-08-2015, coll. Shakoor Ahmed.
Distribution. India: Andaman and Nicobar Island, Assam, Bihar, Delhi, Gujarat, Haryana, Himachal Pradesh (Solan: Nalagarh), Jammu and Kashmir, Jharkhand, Karnataka, Meghalaya, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Sikkim, Tamil Nadu, Telangana, Tripura, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Bangladesh, Cambodia, China, Indonesia, Mexico, Myanmar, Northern Mariana Island, Pakistan, Philippines, Taiwan, Thailand, United States, United Kingdom, Vanuatu and Vietnam.
Ecological group. Endogeic.
Zoogeographical distribution type. Exotic peregrine.
Habitat. Forest, cultivation, grassland, orchard, banana plantation, river bank.

Genus *Perionyx* Perrier, 1872

28*. *Perionyx bainii* Stephenson, 1915

Perionyx bainii Stephenson 1915: 72.
Perionyx bainii: Stephenson (1923: 326); Gates (1960: 219).
Distribution. India: Himachal Pradesh (Solan: Chail Sanctuary, Hinner and Junga), Odisha, Uttarakhand, Uttar Pradesh.
Ecological group. Epigeic.
Zoogeographical distribution type. Endemic.
Habitat. Forest, leaf litter.

29. *Perionyx excavatus* Perrier, 1872

Perionyx excavatus Perrier 1872: 126.
Perionyx gruenewaldi: Michaelsen (1891: 33).
Perionyx excavatus: Michaelsen (1900: 208).
Perionyx parvulus: Stephenson (1916: 321).
Perionyx fulvus: Stephenson (1923: 333).
Perionyx excavatus: Gates (1960: 224); Gates (1972: 141); Blakemore (2012: 283).
Material examined: 5 clitellates, 1 aclitellate, locality name Shilli, alt. 1463 m, date of collection 11-08-2014, coll. Shakoor Ahmed.
Distribution. India: Andaman and Nicobar Island, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Himachal Pradesh (Solan: Chail, Hinner, Jarash, Parwanu, Patta, Ramshahar, Sadhupul, Solan and Shilli), Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Odisha, Puducherry, Sikkim, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Australia, Barbados, China, Jamaica, Fiji, Indonesia, Japan, Korea, Madagascar, Malaysia, Mexico, Mozambique, Myanmar, New Zealand, Philippines,

Reunion, Samoa, South Africa, Sri Lanka, Taiwan, Trinidad and Tobago, United Kingdom, United States and Vietnam.
Ecological group. Epigeic.
Zoogeographical distribution type. Native peregrine.
Habitat. Cultivation, forest, grassland, orchard, banana plantation.

30*. *Perionyx sansibaricus* Michaelsen, 1891

Perionyx sansibaricus Michaelsen 1891: 4.
Perionyx sansibaricus: Michaelsen (1909: 174); Stephenson (1923: 356); Gates (1972: 138); Julka and Senapati (1987: 15); Blakemore (2012: 287).
Distribution. India: Delhi, Gujarat, Himachal Pradesh (Solan: Parwanu), Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh. Elsewhere: China, Philippines, Tanzania and Thailand.
Ecological group. Epigeic.
Zoogeographical distribution type. Native peregrine.
Habitat. Forest, river bank, dung heap.

31*.*Perionyx simlaensis* (Michaelsen, 1907)

Perionychella simlaensis Michaelsen 1907: 157.
Perionyx simlaensis: Stephenson (1923: 359); Gates (1960: 234); Julka (1995: 21).
Distribution. India: Haryana, Himachal Pradesh (Solan: Dharampur and Ramshahar), Punjab, Uttarakhand, Uttar Pradesh, West Bengal. Elsewhere: Bangladesh.
Ecological group. Epigeic.
Zoogeographical distribution type. Endemic.
Habitat. Forest, soil rich in organic matter, near irrigation channels.

Genus *Argilophilus* Eisen, 1893

32*. *Argilophilus sadhupulensis* (Julka & Paliwal, 1994)

Plutellus sadhupulensis Julka and Paliwal 1994: 217.
Argilophilus sadhupulensis: Blakemore (2007a: 29).
Distribution. India: Himachal Pradesh (Solan: Sadhupul), Uttarakhand.
Ecological group. Endogeic.
Zoogeographical distribution type. Endemic.
Habitat. Forest, agroforestry.

Key to the identification of earthworm species of Solan

1 – Eight chaetae on each segment in four pairs throughout the body 2
– More than 8 chaetae on each segment throughout the body 21

2 – Male pores at intersegmental furrow 10/11 3
– Male pores behind segment 11 4

3 – Genital markings present, spermathecal atrium pear or finger shaped .....
..... *Drawida japonica*
– Genital markings absent, spermathecal atrium saccular .. *Drawida nepalensis*

4 – Male pores on segment 13 or 15 5
– Male pores behind segment 15 11

5 – Male pores on segment 13 ..... *Eiseniella tetraedra tetraedra*
– Male pores on segment 15 6

6 – First dorsal pore at furrow 4/5 or 5/6, clitellum begins before segment 27 ... 7
– First dorsal pore at or behind furrow 9/10, clitellum begins at or behind segment 27 9

7 – Clitellum in segments 24–30, tubercula pubertatis absent .... *Bimastos parvus*
– Clitellum begins behind segment 24, tubercula pubertatis present 8

8 – Pale or light pink coloured worms, calciferous sacs present in segment 10
..... *Aporrectodea rosea rosea*
– Worms red coloured with yellow transverse stripes, calciferous sacs absent in segment 10 ..... *Eisenia fetida*

9 – Clitellum on segments 27–34 10
– Clitellum on segments 30–35 ..... *Octolasion tyrtaeum*

10 – Tubercula pubertatis smooth, chaetae ab genital tumescences absent on segment 33 ..... *Aporrectodea caliginosa trapezoides*
– Tubercula pubertatis interrupted slightly at segment 32 with a median concavity of the ventral margin, chaetae ab genital tumescences present on segment 33 ..... *Aporrectodea caliginosa caliginosa*

11 – Dorsal pore present 12
– Dorsal pore absent ..... *Ocnerodrilus occidentalis*

12 – Clitellum covering 7–8 segments; male genital area within clitellum 13
– Clitellum covering 4–5 segments; male genital area not entirely within clitellum 14

13 – Seminal grooves short extending between segment 17 and intersegmental furrow 17/18; female pores paired ..... *Dichogaster saliens*
– Seminal grooves long, extending between segments 17 and 19; female pore single and median ..... *Dichogaster bolaui*

14 – Male pores on segment 18; and female pores on segment 14 15
– Male pores on segment 17; and female pores on segment 13 19

15 – Seminal grooves absent; oesophagus with single gizzard ..... *Argilophilus sadhupulensis*
– Seminal grooves present; oesophagus with 2 gizzards 16

16 – Seminal grooves short extending between segment 17 and intersegmental furrow 17/18 17
– Seminal grooves long, extending between segments 17 and 19 18

17 – Ventral most chaetae on segment 8 enlarged ..... *Lennogaster chittagongensis*
– Ventral most chaetae on segment 8 not enlarged ..... *Lennogaster pusillus*

18 – Spermathecal pores closely placed, near mid ventral line on segments 8 and 9 ..... *Octochaetona beatrix*
– Spermathecal pores widely placed, just posterior to intersegmental furrows 7/8 and 8/9 ..... *Ramiella bishambari*

19 – Small size worms, length <50mm; chaetae converging near male pores; spermathecal pores at intersegmental furrow 8/9 .... *Microscolex phosphoreus*
– Large size worms, length >50mm; chaetae in straight lines through the body; spermathecal pores at intersegmental furrow 7/8 20

20 – Male pores superficial (avestibulate); genital markings restricted to clitellum segments, at 13–16 ..... *Eutyphoeus incommodus*
– Male pores in deep vestibula (vestibulate), genital markings on other segments also ..... *Eutyphoeus waltoni*

21 – Clitellum covering 3 segments 14–16 22
– Clitellum covering more than 3 segments 28

22 – Male pores superficial discharging directly on to body surface 23
– Male pores in copulatory pouches 26

23 – Spermathecal pores 2 pairs, at intersegmental furrows 5/6/7 .... *Amynthas morrisi*
– Spermathecal pore more than 2 pairs 24

24 – Spermathecal pores 3 pairs 25
– Spermathecal pores 4 pairs, at intersegmental furrows 5/6/7/8/9 ... *Amynthas corticis*

25 – Spermathecal pores in intersegmental furrows 5/6/7/8 ..... *Amynthas gracilis*
– Spermathecal pores in intersegmental furrows 6/7/8/9 .. *Amynthas hupeiensis*

26 – Spermathecal pores 3 pairs 27
– Spermathecal pores 4 pairs located in intersegmental furrows 5/6/7/8/9; genital markings paired on equators of segments xvii and xix ..... *Metaphire posthuma*

27 – Spermathecal pores in intersegmental furrows 5/6/7/8; genital markings absent ..... *Metaphire birmanica*
– Spermathecal pores in furrows 6/7/8/9; genital markings small within copulatory pouches and spermathecal pore invaginations, recognizable internally by the presence of stalked glands ..... *Metaphire houlleti*

28 – Some ventral most chaetae on anterior part of body much enlarged than their neighbors ..... *Lampito mauritii*
– Ventral most chaetae not enlarged 29

29 – Spermathecal pores 2 pairs, in intersegmental furrows 7/8/9 30
– Spermathecal pores 3 pairs in intersegmental furrows 6/7/8/9 ..... *Perionyx sansibaricus*

30 – Male genital field with elongated penes, last pair of hearts in segment xiii ..... *Perionyx simlaensis*
– Male genital field without penes, last pair of hearts in segment xii 31

31 – Male pores as transverse slits on slightly raised elliptical areas, near mid ventral line; 4–5 chaetae between male pores ..... *Perionyx excavatus*
– Male pores as longitudinal slits, each overhung by a small tubercle, widely separated, 12–18 chaetae between male pores ..... *Perionyx bainii*

Discussion

The present paper reveals the presence of 32 species / subspecies of earthworms from Solan, which represent about 60% of the fauna (53 species) of western Himalaya (Paliwal and Julka 2005; Kumari et al. 2017; Ahmed and Julka 2017), and about 7.5% (426 species / subspecies) of country (Narayanan et al. 2019a). The earthworm species reported in the present study belong to seven families *viz.* Moniligastridae, Lumbricidae, Ocnerodrilidae, Acanthodrilidae, Benhamiidae, Octochaetidae and Megascolecidae. Among the recorded families, Megascolecidae is the most diverse, represented by 13 species, followed by Lumbricidae 7 species, Octochaetidae 6 species, Benhamiidae 2 species, and Ocnerodrilidae and Acanthodrilidae with one species each.

Although the earthworm fauna of the country is represented with high level of endemism, about 71% of genera and 89% species are endemic (Julka et al. 2007), but in the present study area exotic peregrine species predominate the native species. Among the recorded species, 19 are exotic peregrine, 10 native peregrine and three endemic or near endemic to the study area. The exotic peregrine species are *Drawida japonica*, *Aporrectodea caliginosa caliginosa*, *A. caliginosa trapezoides*, *A. rosea rosea*, *Eisenia fetida*, *Eiseniella tetraedra tetraedra*, *Octolasion tyrtaeum* (Palearctic origin); *Bimastos parvus, Ocnerodrilus occidentalis* (Nearctic origin); *Microscolex*

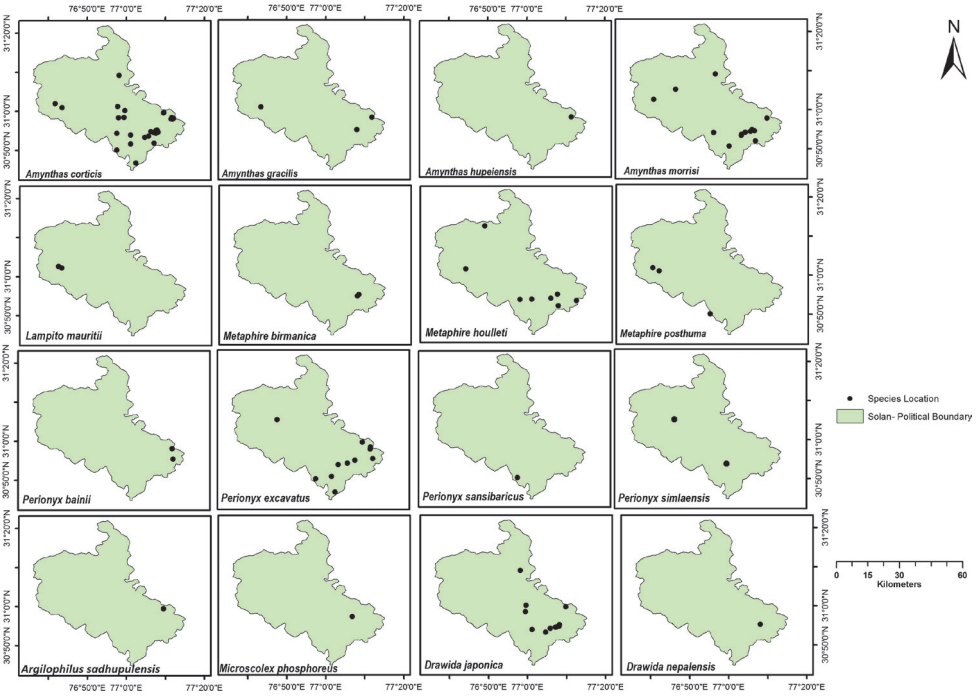

Figure 2. Distribution of earthworm species in Solan, Himachal Pradesh, India.

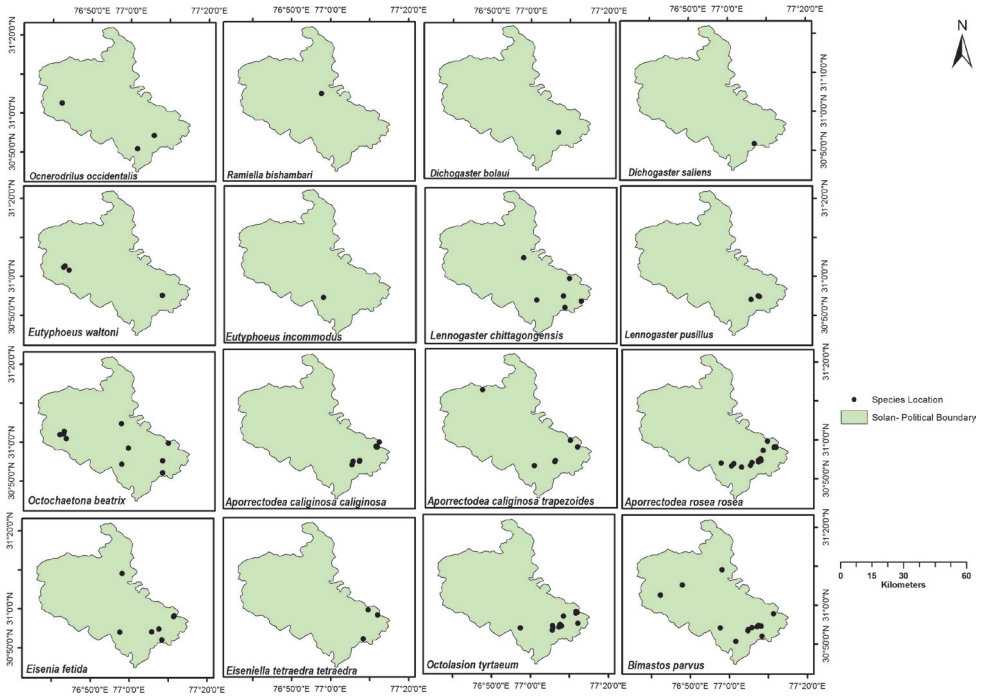

Figure 3. Distribution of earthworm species in Solan, Himachal Pradesh, India.

phosphoreus (Neotropical Origin); *Dichogaster bolaui*, *D. saliens* (Ethiopian origin); *Metaphire birmanica*, *M. houlleti* and *M. posthuma* (Southeast Asia); *Amynthas corticis*, *A. gracilis*, *A. hupeiensis*, *A. morrisi* are native to the China (Gates 1972; Julka 1988; Paliwal and Julka 2007; Narayanan et al. 2016a). These exotic peregrine species are possibly transported to these hills through the soil around roots of exotic plants and other agencies (Julka and Paliwal 2005a). At present, these exotic species are highly distributed near human habitations. Till date, there is no such report which shows the impact of exotic earthworm species on forest ecosystem of the region, but several studies in North America have documented the effect of invasive earthworm species on forest ecosystem *e.g.* decrease in the thickness of forest floor, increase the soil compaction, nutrient leaching and also negatively effects the native plants and animal species (Scheu and Parkinson 1994; Bohlen et al. 2004; Hale et al. 2008; Maerz et al. 2009; Loss and Blair 2011).

Ten species from other biogeographical regions of the country are also found in the study area, among them, *Drawida nepalensis*is, endemic to the Nepal, *Eutyphoeus incommodus* and *E. waltoni* are endemic to the adjacent Indo-Gangetic plains, the species of genera *Lennogaster*, *Octochaetona* and *Ramiella* reported in the present manuscript are endemic to the central highlands of the peninsula, *Perionyx excavatus* (eastern Himalaya), *Perionyx sansibaricus* (Indian Peninsula)

and *Lampito mauritii* is endemic to the Western Ghat (Gates 1947; Paliwal and Julka 2007).

The endemic or near endemic earthworm species of region comprise of three species *Argilophilus sadhupulensis*, *Perionyx simlaensis* and *P. bainii*. Several studies were undertaken on the earthworm diversity of Himachal Pradesh, except (*P. simlaensis*) no one report the presence of these endemic species near or in the region of their type localities. However, a recent study of Joshi et al.(2010) documented *Argilophilus sadhupulensis* from Uttarakhand, and *Perionyx bainii* from Odisha (Goswami 2018). More studies are required to understand the present status of these endemic species. The area of the present study is dominated by exotic peregrine species, and it may also became interested to study the impact of invasive earthworm species on the endemic element. As, Vitousek (1990) and Bholen et al. (2004) reported that by altering the habitat and available resources the biological invasion compete or replace the native species.

Further range expansion of *Lampito mauritii*, *Eutyphoeus waltoni* and *Metaphire posthuma* are observed during the present study, as *Lampito mauritii* is recorded first time from Western Himalaya, whereas *Metaphire posthuma* and *Eutyphoeus waltoni* are recorded first time from the study sites. Warming of the western Himalayan region may be the reason for range expansion of these species. The temperature of western Himalaya is rising (Kothawale et al. 2010), and Addison (2008) reported that even a small increase in winter temperature leads to increase in earthworms habitat.

Conclusion

To date, 32 (past and present record) species of earthworm have been reported from district Solan. Among the recorded families, Megascolecidae is the most diverse family with 13 species, and the largest genera having maximum species are *Amynthas* and *Perionyx* each with four species in the study site. Further range expansion of *Lampito mauritii*, *Eutyphoeus waltoni* and *Metaphire posthuma* are observed during the present study, as *Lampito mauritii* is recorded first time from Western Himalaya, whereas *Metaphire posthuma* and *Eutyphoeus waltoni* are recorded first time from the study sites. Earthworm act as an indicator of biotic pressure and vegetation change, the predominance of exotic peregrine species (59.3%) over native indicates a high degree of disturbance in the area.

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