Diversity and Abundance of Delineated Earthworm (Annelida: Clitellata) in Pakistan: A Review

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Abstract: Earthworm, a ubiquitous (but neglected) macro-invertebrate, is found in terrestrial vicinity of Pakistan. Moreover, the occurrence of earthworms is often diverse with fluctuating quantity depending upon abiotic factors and land usage patterns. The aim of this study was to summarize all the reported information related to earthworm diversity in different areas of Pakistan. Almost all the data published from year 2001 to 2021 were collected. Following data organization, total 42 earthworm’s species including five families (Acanthodrilidae, Lumbricidae, Moniligastridae, Octochaetidae and Megascolecidae) were reported from various researchers. Among five families, family Acanthodrilidae was found to have only one specie (Ramiella bishambiri), Lumbricidae consist of 10 species (Apporactodea rosea, Allobophora trapezoids, Allophophora chlorotica, Aporrectodea longa, A. caliginosa, Bimastus parvus, Eisenia fetida, Helodrilus foetidus, Lumbicus terrestries and L. rubilus), Moniligastridae has two species (Dravida nepalensis and D. pellucida) while Octochaetidae possess only one specie (Eutypheus incommodus). The most abundant and diverse family Megascolecidae consist of 28 earthworm species in all habitats of different regions of Pakistan. Among geographical areas, Faisalabad was found as the richest territory with most reported earthworm species (i.e. 28). The current study suggests further in depth research to explore the unidentified and/missing species of earthworms in Pakistan.

Key words: earthworm, Anneldida, diversity, Lumbricidae, Megascolecidae, Pakistan

1 Introduction

Pakistan is a broad country (796,096 km²) of South Asia and is surrounded by India (East), China (North-East), Afghanistan (North-West), Iran (West) and 650 miles lengthy coastline along Arabian sea (South). Its land is divided into 4 major provinces Punjab, Baluchistan, Sindh, Khyber Pakhtunkhwa and federal area of Islamabad capital. Moreover, there are two other administrative divisions of Pakistan i.e., Gilgit-Baltistan and Azad Jammu and Kashmir (Fig. 1). The water ways of Pakistan consist of Jhelum, Sutlej, Ravi, Chenab river, with all originated from Indian territory and enter from southwestward into Pakistan land, draining in the Indus basin river. The west of Pakistan is arid which lacks rivers for draining soil³.

Pakistan has all four seasons, moderate temperature during spring, driest, cold winter and hottest summer followed by autumn full of rainy seasons³. The climate and draining system (rivers and canals) of Pakistan has great impact on soil fertility and support above 80% of the total biomass of earthworms from soil fauna and flora⁴. Among soil fauna, earthworms are bountiful macro-invertebrates in terrestrial environment⁴,⁵. Generally, these soil worms dialectically called as soil or ecosystem engineers, are vital for soil fertility and quality⁶. Earthworms, known as night-crawlers, are belong to phylum Anneldida, class Clitellata with 16 families. They are world wide distributed invertebrates and comprise of over 5,500 known earthworm species⁷, while among these, 590 species of earthworm diversified in south Asia, including Pakistan⁸. However, first official record of earthworm’s fauna from south Asia was determined by Templeton in 1844⁹. Later, various species were remarkably identified and added by different taxono-
mists in the Asian subcontinent9, 10. Similarly, in 1916, earthworms of Lahore (before partition) were previously described by Parshad11. After Partition, Bhatti (a taxonomist) was the first researcher, who identified and confirmed the various earthworm species in different areas of Lahore12. Subsequently, a number of researchers also examined and confirmed the existence of earthworms in different regions of Pakistan13-15. Now recently, earthworm identification through DNA barcoding technique by utilizing COI gene sequence was also reported for the first time for Sialkot locality, Pakistan5.

Pakistan is richest in soil macrofauna like earthworms which increase soil fertility. Although, earthworm species are attentively studied all around the world, they are feebly neglected living organism in Pakistan. Our study is an attempt to summarize the short available online data. The aims and objectives are to sum up the maximum available online reported data on earthworm diversity in different regions of Pakistan.

2 Material and Methods

Online published articles of earthworm, a native community of soil macrofauna, studies from 2001 to 2021 were downloaded and sorted with respect to our objectives by employing search engine PubMed and Google Scholar. All the selected articles were read and relevant data was sorted. The online surveyed data was organized in tabulate and statistically analyzed via software origin pro 9.0 2022 to construct graph and chart16.

3 Results

3.1 Earthworm diversity in Pakistan

The earthworm species abundance and diversity at a specified area is affected by the soil qualities (i.e. organic contents, climate and water level), history of land utilization for crop cultivation and seasonal variations17. Moreover, certain abiotic physicochemical factors like temperature, pH, nitrogen concentration, availability of phosphorous and potassium, also have great impact on diversity of earthworms19. From analysis of cited data, there are 42 reported earthworms, and these worms belong to five families including Acanthodrilidae, Lumbricidae, Megascolecidae, Moniligastridae and Octochaetidae. Among these families, member of Megascolecidae possess high rank among all the available earthworm families in Pakistan (Fig. 2). Many researchers have marked earthworm diversity in different areas of Pakistan such as Sargodha19, Gujranwala14, Islamabad15, 23, Faisalabad4, 13, Narowal18, Lahore22, Bahawalpur20, 21, Multan21, Sialkot5, and Poonch17 (Table 1).

3.2 Habitats of earthworms

Earthworm community dynamics relationship with different habitats and soil forms was well documented all over the world17 except for Pakistan. Analysis of collected data from relevant research articles represented that 26% earthworm species were found in different habitats such as crop fields, orchids and near water reservoirs of Faisalabad territory. Following Faisalabad, Gujranwala and Lahore were observed to have 17% and 9% earthworm diversity, respectively while 12% diversity was found in both Sialkot and Poonch (Fig. 3). These variations in species richness may be due to increase level of soil fauna or highest re-
Table 1  The reported data of all earthworm species with their names, habitats, areas and sources.

| Families       | Earthworm species                  | Habitats                                              | Area /District | Reported by       |
|----------------|-----------------------------------|-------------------------------------------------------|----------------|-------------------|
| Acanthodrilida | Ramiella bishambari               | Wheat, Green, Chili                                   | Gujranwala     | 14                |
|                |                                   | Botanical garden                                      | Lahore         | 22                |
|                | Apporactodea rosea                | Green, Chili                                          | Gujranwala     | 14                |
|                |                                   | Crop fields, municipal solid waste, river bank, stagnant and spring water bank | Poonch (Azad Kashmir) | 17                |
|                | Allolobophora trapezoides         | Botanical garden                                      | Lahore         | 22                |
|                | Allolobophora chlorotica          | Crop fields, cow dung, municipal solid waste, dumped areas, near water bodies like river, stagnant water | Poonch (Azad Kashmir) | 17                |
|                | Bimastus parvus                   | Botanical garden                                      | Lahore         | 22                |
|                |                                   | Crop fields, cow dung, municipal solid waste, near water bodies | Poonch (Azad Kashmir) | 17                |
|                | Helodrilus foetidus               | Various Croplands                                     | Narowal        | 18                |
|                | Lumbricus terrestris              | Mango orchards                                        | Bahawalpur & Multan | 21                |
|                |                                   | Crop lands, partially decomposed cow dung and garden soil | Poonch (Azad Kashmir) | 17                |
|                | Lumbricus rubillus                | Various Croplands                                     | Narowal        | 18                |
|                | Aporrectodea longa                | Mango, Citrus and Date Palm fields                    | Faisalabad     | 04                |
|                |                                   | Crop fields, cow dung, municipal solid waste, near water bodies | Poonch (Azad Kashmir) | 17                |
|                | Aporrectodea caliginosa           | Mango and Date Palm fields                            | Faisalabad     | 04                |
|                |                                   | Crop fields, cow dung, municipal solid waste, near water bodies | Poonch (Azad Kashmir) | 17                |
|                | Eisenia fetida                   | Cow manure                                            | Islamabad      | 23                |
|                |                                   | Mango orchards                                        | Multan         | 21                |
|                |                                   | Crop fields, dumped areas, cow dung, municipal solid waste, river bank and near other water bodies like spring and stagnant water | Poonch (Azad Kashmir) | 17                |
|                | Amynthas agrestis                 | Canal bank                                            | Sialkot        | 05                |
|                | Lampto mauritii                  | Wheat, Bitter, Gourd, Pumpkin, Soehghum, Jantar       | Gujranwala     | 14                |
|                |                                   | Botanical garden                                      | Lahore         | 22                |
|                | Lampto templetonianus             | Soehghum, crop fileds                                 | Gujranwala     | 14                |
|                | Lampto trilobatus                 | Soehghum, Pumpkin                                     | Gujranwala     | 14                |
|                | Lampto williyyi                  | Pumpkin, Bitter                                       | Gujranwala     | 14                |
|                | Perionyx excavates                | Crop fields, cow dung, municipal solid waste, near water bodies | Poonch (Azad Kashmir) | 17                |
|                | Phereitima anomola / Metaphire anomola | Mango, Guava and Date Palm fields                     | Faisalabad     | 04                |
|                |                                   | Canal bank                                            | Sialkot        | 05                |
|                | Phereitima birmanica / Metaphire birmanica | Jantar, Guava and Mulberry fields                     | Gujranwala     | 14                |
|                |                                   | Cana bank                                             | Faisalabad     | 04                |
|                |                                   | Sialkot                                               | 05              |
|                | Phereitima bournei                | Different crop fields                                 | Bahawalpur     | 20                |
|                | Phereitima bureliamess           | Different crop fields                                 | Bahawalpur     | 20                |
|                | Phereitima california / Metaphire california | Mango, Guava and Date Palm fields | Faisalabad | 04                |
|                |                                   | Canal bank                                            | Sialkot        | 05                |
|                | Phereitima dffringens / Metaphire dffringens | Various Croplands, Mango, Citrus, Guava and Date Palm fields | Faisalabad | 04                |
|                |                                   | Botanical garden                                      | Lahore         | 22                |
|                |                                   | Sialkot                                               | 05              |
|                | Phereitima suctorial              | Mango, Guava and Mulberry fields                      | Faisalabad     | 04                |
|                | Phereitima borna                  | Mango and Date Palm fields                            | Faisalabad     | 04                |
|                | Phereitima elongate               | Soehghum, Jantar                                      | Gujranwala     | 14                |
|                | Phereitima hayayana /            | Water channels, Water ditches, Canal bank, River bank  | Faisalabad & Sargodha | 13                |
|                |                                   | Mango, Guava and Date Palm fields                     | Gujranwala     | 14                |
|                |                                   | Cana bank                                             | Islamabad      | 15                |
|                | Phereitima gracilis               | Grassy lawns, pond banks                              | Faisalabad     | 04                |
|                |                                   | Mango and Citrus fields                               | Sialkot        | 05                |
search interest in that area. Although, most regions of Pakistan have not mentioned in this study due to absence of study proof or lack of published data. Previously, active association between few earthworm species (P. posthuma, P. morrisi and P. hawayana) and agroecosystem was studied in Sargodha and Faisalabad\(^{13}\). They have also reported the significant association of these species with various habitats like water channels, grass lands, crop land, agricultural practices and orchards. Meanwhile, some researchers determined the significant relationship between earthworm biodiversity, moisture level and variety of vegetations\(^{19, 22}\). Similarly, the burrowing behaviour and relative richness in various regions such as forest, grass land, agricultural land and river banks were studied\(^{18}\). They identified 8% Moniligastridae, 12.05% Lumbricidae and most abundant 73.3%

**Table 1** Continued.

| Families      | Earthworm species | Habitats                                                                 | Area /District              | Reported by         |
|---------------|-------------------|--------------------------------------------------------------------------|----------------------------|---------------------|
| Megascolecida | Pheretima heterochaeta | Green, Chili, Bitter, Gourd, Pumpkin, Sorghum, Jantar                      | Gujranwala 14              |                     |
|              |                   | Citrus field                                                              | Faisalabad 04              |                     |
|              | Pheretima lignicola | Bitter, Gourd, Pumpkin                                                    | Gujranwala 14              |                     |
|              |                   | Mango, Citrus, Guava, Mulberry and Date Palm fields                       | Faisalabad 04              |                     |
|              |                   | Canal bank                                                                 | Sialkot 05                |                     |
|              | Pheretima minima / | Various Croplands                                                         | Narowal 18                 |                     |
|              | Amynthas minimus   | Mango, Citrus, Guava, Mulberry and Date Palm fields                       | Faisalabad 04              |                     |
|              |                   | Canal bank                                                                 | Sialkot 05                |                     |
|              |                   | Crop fields, cow dung, municipal solid waste, near water bodies           | Poonch (Azad Kashmir) 17   |                     |
|              | Pheretima morrisi /| Water channels, water ditches, canal bank, river bank                     | Faisalabad & Sargodha 13   |                     |
|              | Amynthas morrisi   | Grassylaws, pond banks                                                   | Islamabad 15              |                     |
|              |                   | Guava and Mulberry fields                                                 | Faisalabad 04              |                     |
|              |                   | Various Croplands                                                         | Narowal 18                |                     |
|              |                   | Canal bank                                                                | Sialkot 05                |                     |
|              | Pheretima posthuma /| Water channels, water ditches, canal bank, river bank                     | Faisalabad & Sargodha 13   |                     |
|              | Metaphire posthuma | Wheat, Green, Chili, Bitter, Gourd, Pumpkin, Sorghum, Jantar              | Gujranwala 14              |                     |
|              |                   | Graslyaws, pond banks                                                     | Islamabad 15              |                     |
|              |                   | Mango, Guava, Mulberry and Date Palm fields                               | Faisalabad 04              |                     |
|              |                   | Botanical garden                                                          | Narowal 18                |                     |
|              |                   | Various Croplands                                                         | Lahore 22                 |                     |
|              |                   | Canal bank                                                                | Bahawalpur 20             |                     |
|              |                   |                                                                          | Sialkot 05                |                     |
|              | Pheretima suctorial | Green, Chili, Bitter, Gourd, Jantar                                      | Gujranwala 14              |                     |
|              | Pheretima carinensis | Mango, Guava and Date Palm fields                                        | Faisalabad 04              |                     |
|              | Pheretima taprobanae | Bitter, Gourd, Sorghum                                                    | Gujranwala 14              |                     |
|              |                   | Mango and Date Palm fields                                                | Faisalabad 04              |                     |
|              | Metaphire mouritici | Guava field                                                               | Faisalabad 04              |                     |
|              | Pheretima osmastonia | Citrus field                                                             | Faisalabad 04              |                     |
|              | Pheretima houlleti /| Citrus field                                                              | Faisalabad 04              |                     |
|              | Metaphire houlleti  | Canal bank                                                                | Sialkot 05                |                     |
|              | Amynthas hupensis  | Crop fields, cow dung, municipal solid waste, near water bodies           | Poonch (Azad Kashmir) 17   |                     |
|              |                   |                                                                          | Lahore 22                 |                     |
|              | Drawida nepalensis | Botanical garden                                                          | Lahore 22                 |                     |
|              |                   | Dumped areas like near water bodies, cow dung pile, crop fields, municipal solid waste | Poonch (Azad Kashmir) 17 |                     |
| Moniligastrida |                   |                                                                          | Lahore 22                 |                     |
|              | Drawida pellucida  | Various Croplands                                                         | Gujranwala 14              |                     |
|              |                   |                                                                          | Faisalabad 04              |                     |
|              | Eutychoeus incommodus | Green, Chili                                                             | Lahore 22                 |                     |
| Octochaetida  |                   | Mango field                                                               | Gujranwala 14              |                     |
|              |                   | Botanical garden                                                          | Faisalabad 04              |                     |

![Fig. 3](image-url) A chart indicating published earthworm diversity in different regions of Pakistan.
Diversity and Abundance of Delineated Earthworm (Annelida: Clitellata) in Pakistan: A Review

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...collected different number of earthworm species inhabiting various fields i.e. 06, 09, 10 and 11 species from mulberry, citrus, date palm and guava, respectively. Moreover, E. fetida species was dominated in all kinds of habitats in different regions of Pakistan.

4 Conclusion
To date, 42 (Published data from year 2001 to 2021) earthworm species have been delineated from various habitats of different regions of Pakistan. Among the five explored families namely Megascolecidae (28), Lumbricidae (10), Moniligastridae (02), Acanthodrilidae (01) and Octochaetidae (01), Megascolecidae is highly diverse with 28 species, from which Pheretima is the largest genera with 20 species in all the study areas. While studying territory, analysis of published data represented that 26% earthworm species were marked in the various habitats like agricultural fields, garden soil, orchids, grass lands and near water bodies of Faisalabad. Meanwhile, Lahore and Gujranwala were considered to have 9% and 17% earthworm species diversity, respectively, while 12% species were found in both Poonch and Sialkot. This study highlights the need of more work on earthworms to explore the species diversity in non-study area of Pakistan.

Author’s Contribution
IL designed study, MH analyzed data; or wrote the manuscript. SA, NA, MU, BNK, U and MFQ contributed to information in the submitted manuscript. All authors read and approved the final form of manuscript.

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