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# An Overview of Earthworm Biodiversity in Afghanistan with New Records for the Country (Clitellata: Megadrili)

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## Abstract

In this paper a batch of earthworms from Afghanistan was studied and previous reports on the earthworm fauna of the country were evaluated. In the present study, earthworms were collected by digging and hand sorting, and fixed in 80% ethanol. Six species belonging to three families were identified. They are *Aporrectodea caliginosa*, *Ap. rosea*, *Eiseniella tetraedra*, *Drawida annandalei*, *Amyntas corticis*, and *Metaphire bahli*. Among them *A. corticis*, *Ap. caliginosa*, *D. annandalei*, and *M. bahli* are new records for the country. Nine species have previously been reported from Afghanistan of which two were collected in the current survey as well. Therefore, this study in Afghanistan increased the number of earthworm species registered for the country from 9 to 13 belonging to nine genera and three families. Out of the 13 species, 10 (*Ap. caliginosa*, *Ap. jassyensis*, *Ap. trapezoides*, *Ap. rosea*, *Bimastus parvus*, *Dendrobaena byblica*, *D. fedtschenkoii*, *Eisenia fetida*, *Eis. tetraedra*, and *Lumbricus rubellus*) belong to the Holarctic family Lumbricidae, two species (*M. bahli* and *A. corticis*) to the family Megascolecidae, and one species (*D. annandalei*) to Moniligastridae. Most of the species (10) are peregrine and only three of the lumbricid species in Afghanistan are regarded as autochthonous, viz., *Ap. jassyensis*, *D. byblica*, and *D. fedtschenkoii*. The diversity and distribution of earthworms in Afghanistan is far from complete. To fill this gap in our knowledge on the earthworm fauna of the studied region more detailed investigations are needed to explore the earthworm fauna of this vast country.

**Key words:** *Aporrectodea caliginosa*, *Amyntas corticis*, *Drawida annandalei*, *Metaphire bahli*, *Lumbricidae*, *Megascolecidae*, *Moniligastridae*.

## INTRODUCTION

Afghanistan is a landlocked and mountainous country in southern Central Asia. This country is bordered by Iran to the west; Turkmenistan, Uzbekistan, and Tajikistan to the north; China to the northeast; and Pakistan to the east and south. Physical geography in Afghanistan includes rugged mountains (northern three-quarters of the country) and desert plains. Despite having numerous rivers, large parts of the country are dry (Fisher, 2003; Gritzner & Shroder, 2007). Climatically, Afghanistan is similar to Iran and the Middle East (Barlow *et al.*, 2016).



Very little research has been done on invertebrates in Afghanistan and the information that is available has not been combined. The most of biodiversity investigation was conducted prior to the outbreak of war in 1979. Thereafter, the deteriorating security situation has been made it difficult for researchers to safely survey the country and conduct research activities (UNEP, 2008; MoAIL, 2009; NBSAP, 2014). For this reason, hitherto, little is known about the biodiversity and distribution of earthworms in Afghanistan. The only available published resources are three old faunistic surveys which published by Omodeo (1959, 1962) and in Gates (1972), listing several taxa of earthworms from the country. The validity of the reported taxa and their presence in Afghanistan needs to be reassessed. Previous reported earthworms are all belonging to Lumbricidae, except for one unidentified Oligochaeta species (as "*Lumbriculus* sp.") that belongs to the family Lumbriculidae.

In this study, we provide new earthworm records for the country and compare it with previous published data. Also, the validity of previously reported species is reassessed.

**TABLE 1.** List, geographic coordinates, and habitat types of sampling locations.

No. of Sampling Site	Locality Name	Latitude (N)	Longitude (E)	Habitat
1	Kapisa	34° 57' 55"	69° 38' 09"	Grassland
2	Heseh Dovom Kohestan	35° 02' 16"	69° 31' 24"	Woodland
3	Kishketan	34° 58' 59"	69° 36' 05"	Grassland
4	Golbahar	35° 07' 25"	69° 18' 23"	Grassland
5	Jamal Agheh	35° 01' 26"	69° 32' 19"	Grassland
6	Khom Zargar	35° 03' 03"	69° 29' 48"	Grassland
7	Rahman Khil	34° 59' 57"	69° 36' 12"	Grassland
8	Kohband	35° 00' 36"	69° 33' 54"	Grassland
9	Ghaleh Sahra	35° 05' 47"	69° 13' 15"	Grassland
10	Heseh Aval Kohestan	35° 03' 51"	69° 29' 59"	Woodland
11	Korreh Taz	34° 57' 26"	69° 40' 58"	Grassland

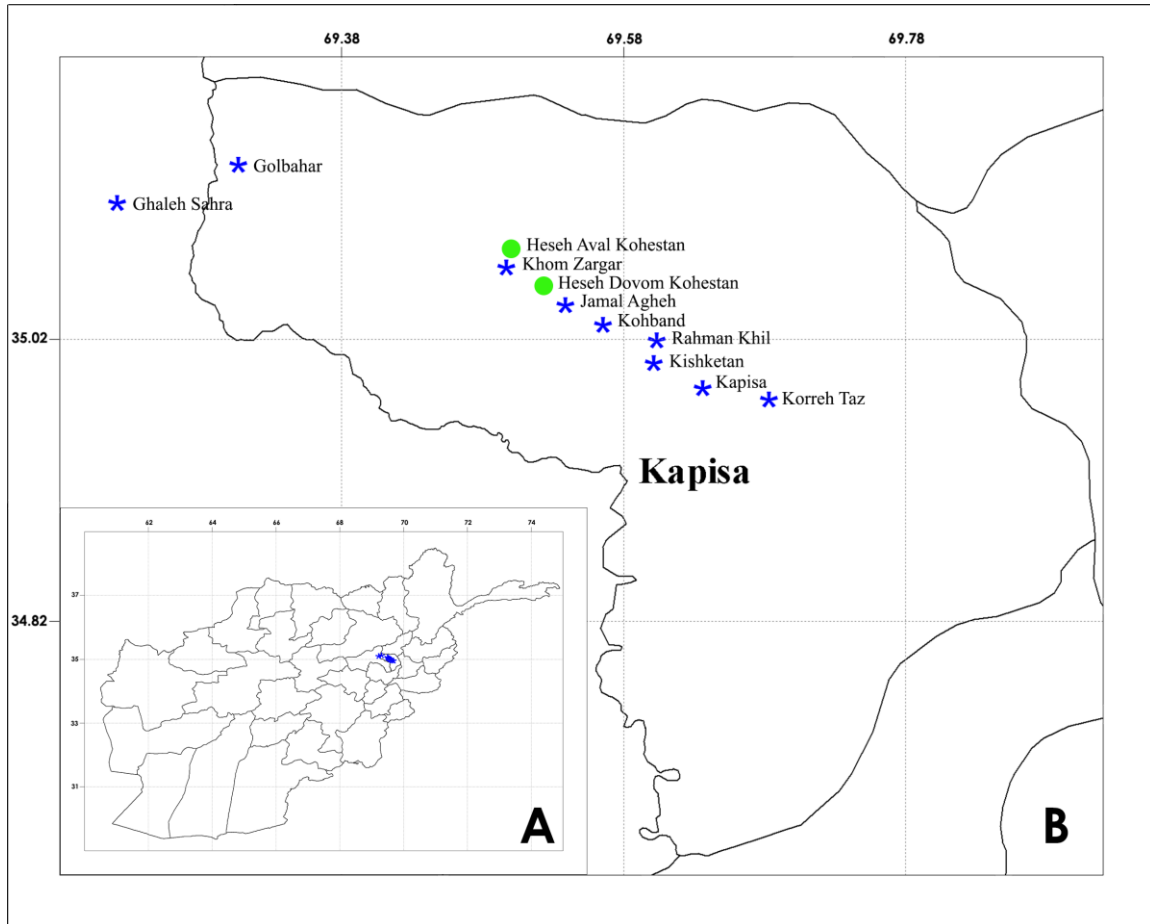
## MATERIAL AND METHODS

Earthworms were collected by digging and hand sorting of 25×25×25 cm soil blocks collected at 11 stations of Kapisa Province, Afghanistan, in April 2018 (Table 1 and Figure 1). Three blocks were examined at each station so altogether we have analysed 33 samples. Collected specimens were anaesthetized in 15% and fixed in 80% ethanol, respectively. Anatomical observations were made by dissection the worms under a stereomicroscope. Specimens were housed in the Zoological Museum of Bu-Ali Sina University (ZMBASU) in Iran. Mature earthworms were identified according to Csuzdi and Zicsi (2003), Sims and Gerard (1999), and Perel (1979).

A similarity matrix was generated using Jaccard's coefficient for earthworm fauna comparison between Afghanistan and neighbouring countries. Dendrogram of similarity was produced based on the Jaccard's index using SPSS ver. 22 software.

## RESULTS

During this study, altogether six peregrine earthworm species belonging to three families were recorded, namely, Lumbricidae (*Aporrectodea caliginosa* (Savigny, 1826), *Ap. rosea* (Savigny, 1826), and *Eiseniella tetraedra* (Savigny, 1826)); Moniligastridae (*Drawida annandalei* Stephenson, 1913); and Megascolecidae (*Amyntas corticis* Kinberg, 1867 and *Metaphire bahli* (Gates, 1945)). The different stations differed in species composition, being *A. corticis* and *M. bahli* the most frequent (found in four stations) and *Eis. tetraedra* and *D. annandalei* were the most uncommon, found in only one station (Table 2).



**FIGURE 1.** Map of sampling locations in studied area. **A.** Afghanistan. **B.** Kapisa Province. **Green Circles.** Woodlands. **Blue Stars.** Grasslands.

### List of species

#### A) Lumbricidae Rafinesque-Schmaltz, 1815

##### A-1) *Aporrectodea caliginosa* (Savigny, 1826)

**Material examined:** (ZMBASU 22), [2 ex. Kapisa ( $34^{\circ} 57' 55''$ ,  $69^{\circ} 38' 09''$ )]; (ZMBASU 23), [2 ex. Golbahar ( $35^{\circ} 07' 25''$ ,  $69^{\circ} 18' 23''$ )]; (ZMBASU 24), [2 ex. Hesh Aval Kohestan ( $35^{\circ} 03' 51''$ ,  $69^{\circ} 59' 29''$ )].

**Habitat:** Grass-woodland.

##### A-2) *Aporrectodea rosea* (Savigny, 1826)

*Allolobophora rosea f. acystis* (Michaelsen, 1902): Omodeo 1959: 6.

*Allolobophora rosea* var.: Omodeo 1962: 6.

*Eisenia rosea*: Gates 1972: 104.

**Material examined:** (ZMBASU 25), [2 ex. Kapisa ( $34^{\circ} 57' 55''$ ,  $69^{\circ} 38' 09''$ )]; (ZMBASU 26), [1 ex. Rahman Khil ( $34^{\circ} 59' 57''$ ,  $69^{\circ} 36' 12''$ )]; (ZMBASU 27), [2 ex. Hesh Aval Kohestan ( $35^{\circ} 03' 51''$ ,  $69^{\circ} 59' 29''$ )].

**Habitat:** Grass-woodland.

**A-3) *Eiseniella tetraedra* (Savigny, 1826)**

*Eiseniella tetraedra* f. *typica*: Omodeo 1959: 8.

*Eiseniella tetraedra*: Omodeo 1962: 9, Gates 1972: 108.

**Material examined:** (ZMBASU 28), [3 ex. Kishketan (34° 58' 59", 69° 33' 54")].

**Habitat:** Stream.

**B) Megascolecidae Rosa, 1891****B-1) *Amyntas corticis* (Kinberg, 1867)**

**Material examined:** (ZMBASU 29), [1 ex. Khom Zargar (35° 03' 03", 69° 29' 48")]; (ZMBASU 30), [2 ex. Jamal Agheh (35° 01' 26", 69° 32' 19")]; (ZMBASU 31), [2 ex. Kohband (35° 00' 36", 69° 33' 54")]; (ZMBASU 32), [1 ex. Korreh Taz (34° 57' 26", 69° 40' 58")].

**Habitat:** Grassland.

**B-2) *Metaphire bahli* (Gates, 1945)**

**Material examined:** (ZMBASU 33), [2 ex. Rahman Khil (34° 59' 57", 69° 36' 12")]; (ZMBASU 34), [1 ex. Jamal Agheh (35° 01' 26", 69° 32' 19")]; (ZMBASU 35), [2 ex. Heseh Dovom Kohestan (35° 02' 16", 69° 31' 24")]; (ZMBASU 36), [1 ex. Korreh Taz (34° 57' 26", 69° 40' 58")].

**Habitat:** Grass-woodland.

**C) Moniligastridae Claus, 1880****C-1) *Drawida annandalei* Stephenson, 1913**

**Material examined:** (ZMBASU 37), [5 ex. Ghaleh Sahra (35° 05' 47", 69° 13' 15")].

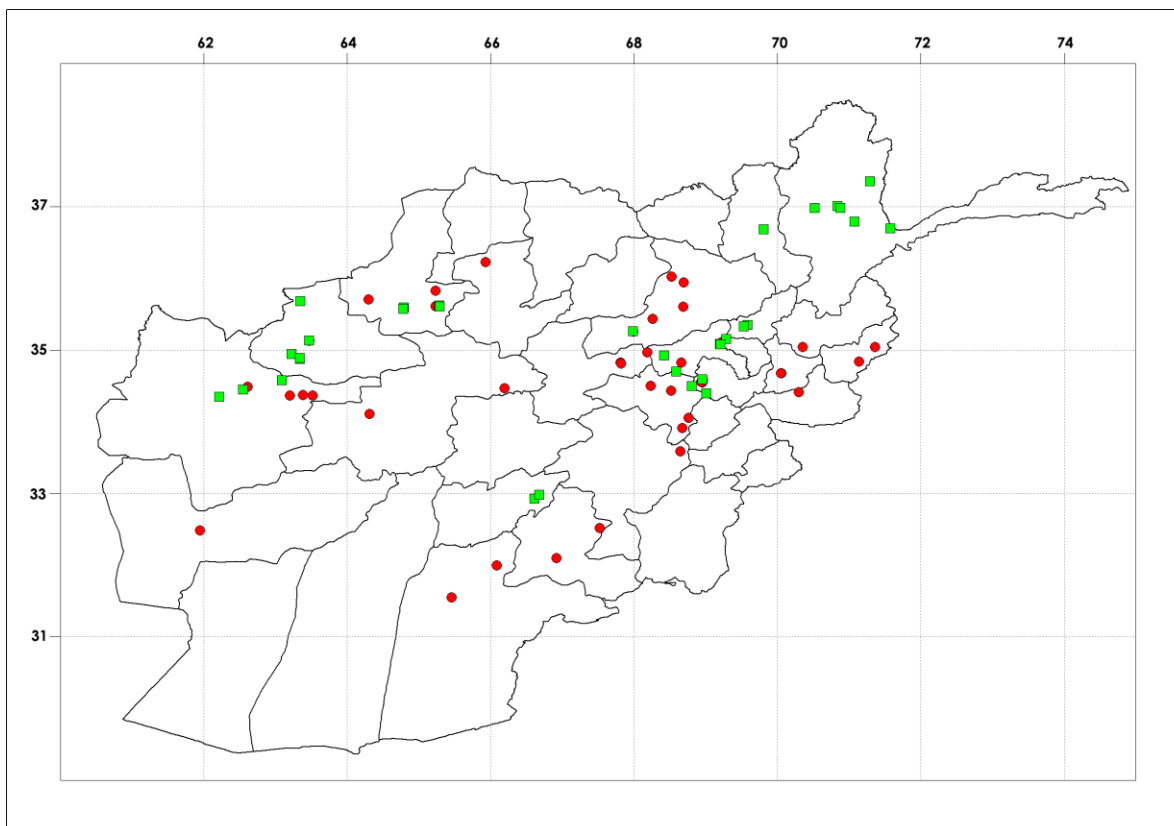
**Habitat:** Grassland.

**DISCUSSION**

Previously only two old documents were published about the earthworm fauna of Afghanistan, *viz.*, Omodeo (1959) and Omodeo (1962). Omodeo (1959) studied a batch of oligochaetes including 151 specimens and assigned them in 10 taxa. The specimens had been collected by Dr. K. Lindberg, at the Lund University, from 43 various localities in Afghanistan (Figure 2 and Table 2). Again, Dr. K. Lindberg sent Omodeo a second batch of oligochaetes, which he had collected from various localities in Afghanistan (Figure 2 and Table 2). Omodeo (1962) studied the specimens and identified them as nine different species, namely *Ap. caliginosa/trapezoides*, *Ap. jassyensis* (Michaelsen, 1891), *Ap. rosea*, *Bimastus parvus* (Eisen, 1874), *Dendrobaena byblica* (Rosa, 1893), *D. fedtschenkoi* (Michaelsen, 1900), *Eisenia foetida*, *Eis. tetraedra*, and *Lumbriculus* sp. Omodeo (1962) pointed out that the second collection has contained the same species as the first one, and they had had in roughly the same proportion; the only novelty had been the finding of *D. fedtschenkoi*.

Gates (1972) in his book on Burmese earthworms reported the occurrence of six species in Afghanistan, namely *Ap. rosea*, *Ap. trapezoides* (Duges, 1828), *B. parvus*, *E. fetida* (Savigny, 1826), *Eis. tetraedra*, and *Lumbricus rubellus* Hoffmeister, 1843; and doubtfully the presence of *D. octaedra* (Savigny, 1826) as well. He stated that the record of *Ap. trapezoides* is based on the study of his own specimens, but he did not mention anything about the other species.

In the present study, six species have been identified which four of them have not been previously reported from this region. *D. annandalei*, as one of the new records for this region, belongs to Moniligastridae. Earthworms of these family are native in the Oriental region (Gates, 1972; Jamieson, 1977; Blakemore *et al.*, 2014). Its natural range encompass south, southeast and east Asia, from peninsular India to Japan through Myanmar, China, extreme southern portion of Far East Russia, Korea,



**FIGURE 2.** Sampling locations of earthworms in Afghanistan. **Red Circles.** First collection (Omodeo, 1959). **Green Squares.** Second collection (Omodeo, 1962).

the Philippines, Borneo, and Sumatra (Gates, 1972). *Drawida* is the most speciose moniligastrid genus that presumably colonized peninsular India after the collision of the Indian plate with Asia during Cenozoic period (Gates, 1972; Blakemore *et al.*, 2014). From the neighbouring countries Pakistan and China, two and 22 species of *Drawida* were reported respectively (Blakemore, 2006; Ghafoor *et al.*, 2008; Zhang & Sun, 2014). As a result, this species may have entered Afghanistan from the southeast or was introduced by man.

The two megascolecid species recorded in this study from Afghanistan (i.e. *A. corticis* and *M. bahli*) are both widely distributed peregrine worms (Blakemore, 2002). *M. bahli* is known mainly from Asia (Cambodia, Laos, Myanmar, Philippines, Sri Lanka, Thailand, and Vietnam) and Australia (Gates, 1945, 1972; Blakemore *et al.*, 2012; Nguyen *et al.*, 2016; Nguyen & Lam, 2017). Of the neighbouring countries, *A. corticis* and five species of *Metaphire* have been reported only from Pakistan (Sarwar *et al.*, 2006; Ghafoor *et al.*, 2008).

The lumbricid species in genera *Aporrectodea* and *Eiseniella* are of European origin (Wood & James, 1993). According to Mršić (1991) the genus *Dendrobaena* appeared on the Southern Aegean land masses, the genus *Eisenia* on the Asian plate, the genera *Aporrectodea* and *Lumbricus* in Western Europe, and the genus *Bimastos* in North America (Csuzdi & Zicsi, 2003). Several lumbricid species show anthropochore distribution, including *Ap. caliginosa*, *Ap. trapezoides*, *Ap. rosea*, *E. fetida*, *Eis. tetraedra*, *L. rubellus*, etc. (Csuzdi & Zicsi, 2003). Until now, only three of the reported lumbricid species in Afghanistan are regarded as autochthonous, viz., *Ap. jassyensis*, *D. byblica*, and *D. fedtschenkoi* (Mısırlıoğlu *et al.*, 2008). *B. parvus*, native in North America, but now they are peregrine and introduced all over the world (Reynolds, 1977).

**TABLE 2.** Localities of the earthworm species studied by Omodeo (1959, 1962) and in present study.

First collection (Omodeo 1959)			Second collection (Omodeo 1962)		
Name of location	Species*	No. of species	Name of location	Species*	No. of species
Tchehel Tan Cave	Apr	1	Tang Lalander	Apc	1
Tchehel Tan	Apc	1	Diaouz	Apc, Apr	2
Haouz-Mahiyan	Eit	1	Paghman	Apc, Bp	2
Tchidjan	Apc	1	Pol Matak	Apc	1
Chahr Golghola	Bp	1	Pol Matak	Apc	1
Bamian	Apc, Eit, Bp	3	Mazaneh	Apj, Apc, Apr, Eit, Dbb	5
Diwal Kol	Apc	1	Bamvardar Aoudak	Lsp, Apc, Apr	3
Salar	Apc, Apr	2	Navalitch	Apc	1
Ziyaret Khvadjehe Safa	Lsp, Apc, Apr, Eit	4	Till Païn	Apc, Eit	2
Paghman	Apj, Apc	2	Kou Najak	Lsp, Dbb	2
Chah Qatar	Apc, Apr, Eit, Dbb	4	Sar-haouz	Apr	1
Douazdah Emam	Apj	1	Chercher	Eit, Dbf	2
Soltanpour	Apr	1	Oal'eh Darreh Zang	Ef, Apc, Apr, Eit, Dbf	5
Pialeh Cave	Apr	1	Oal'eh Darreh Zang	Ef	1
Kouh-Chigui	Apr	1	Masdjed Tchoubi	Apr, Eit	2
Sri Tighi Cave	Apr	1	Herat	Apc	1
Djalala	Apr	1	Karokh Cave	Apr, Dbb	2
Samotch	Apr	1	Darreh Boum	Ef, Apc	1
Sang-Tanab	Apr	1	Between Qal'a-i-Nau and Qaddis	Apc	1
Pul-i-Khomri	Apc, Alsp	1	Qaddis	Apc, Eit, Dbb	3
Sorkh Kotal	Apc	1	Qaddis: Tchehel Dokhteran	Lsp	1
Goti	Apj	1	Ghoroutou	Lsp	1
Zir Chibar	Apc	1	Tirgaran	Apc	1
Doab-i-Mekhzarin	Alsp	1	Faizabad	Apc	1
Jebel os-Siradj	Lsp	1	Shiva Kul Lake	Eit	1
Pol-Matak	Dbb	1	Gazestan	Apc, Apr, Dbb	3
Qaisar	Lgsp	1	Ichkachem	Bp	1
Darreh-Beltchiragh	Apc, Apr	2	Baharak	Eit, Dbb	2
Kham Zindan Cave	Lgsp	1	Baharak	Apc	1
Sar-i-Pul	Apc	1	Orozgan	Apc, Apr	2
Darreh-Boum	Apr, Eit	2	Sabz Tchachmeh	Apc	1
Qal'eh Dahan-Tchakka	Eit, Lgsp	2	Doab-i-Mekhzarin	Apc	1
Qal'a-Shaharak	Apc	1	<b>Present study</b>		
Khvadjehe Tchicht	Apc	1	Kapisa	Apc, Apr	2
Between Tchicht and Soumi	Apc	1	Heseh Dovom Kohestan	Meba	1
Obeh	Apr, Eit	2	Kishketan	Eit	1
Karokh Cave	Lgsp	1	Golbahar	Apc	1
Kalat-i-Ghilzai	Ef, Apc	2	Jamal Agheh	Amco, Meba	2
Sirouas	Alsp	1	Khom Zargar	Amco	1
Pandjvai	Apc, Apr	2	Rahman Khil	Apr, Meba	2
Chahr Safa	Dbb	1	Kohband	Amco	1
Kelidan Cave	Eit	1	Ghaleh Sahra	Dra	1
Kouh-Mostoufi	Apc	1	Heseh Aval Kohestan	Apc, Apr	2
			Korreh Taz	Amco, Meba	2

\***Abbreviations:** Alsp: *Allolobophora* sp.; Amco: *A. corticis*; Apc: *Ap. caliginosa*; Apj: *Ap. jassyensis*; Apr: *Ap. rosea*; Bp: *B. parvus*; Dbb: *D. byblica*; Dbf: *D. fedtschenkoi*; Dra: *D. annandalei*; Ef: *E. fetida*; Eit: *Eis. tetraedra*; Lgsp: *Lumbricidarum* gen. sp.; Lsp: *Lumbriculus* sp. (microdrili); Meba: *M. bahli*.

**TABLE 3.** Jaccard's similarity coefficient matrix for earthworm fauna comparison between Afghanistan and neighbouring countries.

Country	Tajikistan	Turkmenistan	Iran	Uzbekistan	Pakistan
Tajikistan					
Turkmenistan	0.375				
Iran	0.385	0.231			
Uzbekistan	0.480	0.222	0.382		
Pakistan	0.056	0.063	0.067	0.043	
Afghanistan	0.444	0.375	0.286	0.276	0.118

Omodeo (1959) regarded the Afghanistan earthworm fauna as Holarctic because the autochthonous taxa like *Ap. jassyensis* and *D. byblica* are from the family Lumbricidae and no native taxa were found from the neighbouring oriental region. By identifying two species of Megascolecidae and one species of Moniligastridae does not change this position because perhaps all the three species were introduced by human activity.

In short, according to our present and previous literature records, 13 species, nine genera, and three families of earthworms are known to be present in Afghanistan. This number is much lower than the 18 species recorded for the much smaller Jordan, which is also a desert area (Pavlíček & Csuzdi, 2006).

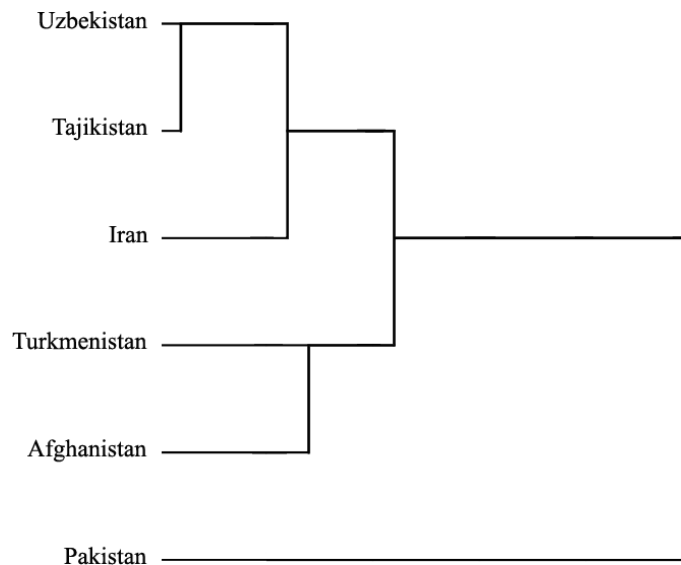
According to current data (Tables 3 and 4), the earthworm fauna of Afghanistan most closely resembles Iran, Tajikistan, and Uzbekistan in terms of number of shared species (8 shared species); Turkmenistan and Tajikistan in respect of percentage of shared species, 66.67% and 61.54%, respectively; and it is most similar to Tajikistan with regard to Jaccard's similarity coefficient (0.444).

**TABLE 4.** Earthworm species in Afghanistan and adjacent countries.

	Uzbekistan	Tajikistan	Iran	Turkmenistan	Pakistan	Afghanistan
<b>Species*</b>	Apc, Apj, Apr, Apt, Bp, Br, Dbb, Dboc, Dbv, Ef, En, Eit, Oc, Ol, Pa, Pc, Pf, Pg, Pk, Pmi, Po, Ps, Pta, Pu	Apc, Apj, Apr, Apt, Bp, Dbb, Dbv, Ef, Eit, Oc, Pk, Pme, Pta	Apc, Apj, Apl, Apr, Apt, Bp, Br, Dbb, Dbh, Dboc, Dbor, Dbp, Dbs, Dbv, Ea, Ef, Em, Eo, Eit, Mid, Mip, Ol, Pk	Apj, Apr, Apt, Ef, Eit, Lr, Pk, Pp, Ptu	Amb, Amca, Amco, Amg, Ami, Aml, Ammi, Ammo, Amo, Ams, Apc, Apl, Dim, Drn, Drp, Ef, Lr, Mea, Mebi, Mec, Meh, Mep, Ob, Pot, Ti	Amco, Apc, Apj, Apr, Apt, Bp, Dbb, Dbf, Dra, Ef, Eit, Lr, Meba
<b>No. of Species (NSS)(PSS)</b>	24 (8) (33.33)	13 (8) (61.54)	23 (8) (34.78)	9 (6) (66.67)	25 (4) (16)	13
<b>References</b>	Omodeo (1959); Rakhmatullae v <i>et al.</i> (2010); Asirovic (2011).	Omodeo (1959); Asirovic (2011).	Farhadi <i>et al.</i> (2013); Szederjesi <i>et al.</i> (2014); Latif <i>et al.</i> (2017); Latif <i>et al.</i> (2018).	Gates (1972); Asirovic (2011).	Sarwar <i>et al.</i> (2006); Ghafoor <i>et al.</i> (2008).	Omodeo (1959, 1962); Gates (1972); Present study.

\***Abbreviations:** Amb: *A. bournei* (Rosa, 1890); Amca: *A. carinensis* (Rosa, 1890); Amco: *A. corticis*; Amg: *A. gracilis* (Kinberg, 1867); Ami: *A. indicus* (Horst, 1885); Aml: *A. lignicolus* (Stephenson, 1914); Ammi: *A. minimus* (Horst, 1893); Ammo: *A. morrisi* (Beddard, 1892); Amo: *A. osmastoni* (Michaelsen, 1907); Ams: *A. suctorius* (Michaelsen, 1907); Apc: *Ap. caliginosa*; Apj: *Ap. jassyensis*; Apl: *Ap. longa* (Ude, 1885); Apr: *Ap. rosea*; Apt: *Ap. trapezoides*; Bp: *B. parvus*; Br: *B. rubidus* (Savigny, 1826); Dbb: *D. byblica*; Dbf: *D. fedtschenkoi*; Dbh: *D. hortensis* (Michaelsen, 1890); Dboc: *D. octaedra*; Dbor: *D. orientalis* (Cernosvitov, 1940); Dbp: *D. pentheri* (Rosa,

1905); Dbs: *D. semitica* (Rosa, 1893); Dbv: *D. veneta* (Rosa, 1886); Dim: *Dichogaster modiglianii* (Rosa, 1896); Dra: *D. annandalei*; Drn: *D. nepalensis* Michaelsen, 1907; Drp: *D. pellucida* (Bourne, 1894); Ea: *E. andrei* Bouche, 1972; Ef: *E. fetida*; Em: *E. malekae* Szederjesi, Latif and Csuzdi, 2014; En: *E. nordenskioldi* (Eisen, 1879); Eo: *E. omranii* Latif, Malek and Csuzdi, 2017; Eit: *Eis. tetraedra*; Lr: *L. rubellus*; Mea: *M. anomala* (Michaelsen, 1907); Meba: *M. bahli*; Mebi: *M. birmanica* (Rosa, 1888); Mec: *M. californica* (Kinberg, 1866); Meh: *M. houletti* (Perrier, 1872); Mep: *M. posthuma* (Vaillant, 1868); Mid: *Microscolex dubius* (Fletcher, 1887); Mip: *M. phosphoreus* (Duges, 1837); Ob: *Octochaetona beatrix* (Beddard, 1902); Oc: *Octolasion cyaneum* (Savigny, 1826); Ol: *O. lacteum* Orley, 1885; Pa: *Perelia arnoldiana* (Perel, 1971); Pc: *P. chlorocephala* (Perel, 1977); Pf: *P. ferganae* (Malevic, 1949); Pg: *P. graciosa* (Perel, 1977); Pk: *P. kaznakovi* (Michaelsen, 1910); Pme: *P. media* (Perel, 1977); Pmi: *P. microtheca* (Perel, 1977); Po: *P. ophiomorpha* (Perel, 1977); Pp: *P. persiana* (Michaelsen, 1900); Ps: *P. stenosoma* (Perel, 1977); Pta: *P. taschkentensis* (Michaelsen, 1900); Pt: *P. turcmenica* (Malevic, 1941); Pu: *P. umbrophila* (Perel, 1977); Pot: *Polypheretima taprobanae* (Beddard, 1892); Ti: *Typhoeus incommodus* Beddard, 1901; NSS: Number of Similar Species with Afghanistan; PSS: Percent of Similar Species with Afghanistan.



**FIGURE 3.** Jaccard's similarity dendrogram for earthworm fauna comparison between Afghanistan and neighbouring countries.

Jaccard's similarity coefficient matrix shows the most similarity of earthworm fauna between Afghanistan and its two northern neighbouring countries, *viz.*, Tajikistan and Turkmenistan (Table 3). This similarity is due to the sharing of Holarctic lumbricid species (Table 4). Afghanistan and Tajikistan share a roughly 1,300 km border, which has the largest shared border after the border with Pakistan. The existence of water resources on the common border of Afghanistan and Tajikistan is perhaps one of the reasons for providing the same conditions. The least Jaccard's similarity coefficient occurs between Afghanistan and Pakistan, in despite of shared existence of the families Moniligastridae and Megascolecidae (Figure 3).

According to Omodeo (1959) the fauna of the former Soviet republics Kyrgyzstan, Tajikistan, Uzbekistan, and Turkmenistan is practically identical to that of Afghanistan. Existing differences will likely diminish or disappear when the fauna survey of these regions will be completed.

Our knowledge about the diversity and distribution of earthworms in Afghanistan and its neighbouring countries is far from complete, since we still have limited data concerning the different parts of Afghanistan and some neighbours of this country. To fill this gap in our knowledge on the earthworm fauna of the studied region more detailed investigations are needed to explore the earthworm fauna of this vast country.



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