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Arthropod diversity in Iran: Class Diplopoda Blainville in Gervais, 1844

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ABSTRACT. Formally, the diplopod fauna of Iran presently contains 54 species from 27 genera, 13 families and eight orders, all listed and supplied with nomenclature, diversity estimates and known species records. Endemism is profound at the species level (ca 80%), but nearly absent at any higher rank. The only and quite remarkable exception is the genus *Chiraziulus*, both species of which are endemic to southern or central Iran. The fauna can generally be considered as Caucasian, part of the eastern Mediterranean realm, *vs* *Chiraziulus* that clearly represents a very ancient and relict group (suborder Cambalidea) presently occurring in the Nearctic (together with the Hawaiian Islands, Pacific Ocean) in the New World, but rather Oriental, both tropical and subtropical, in Indo-Australasia (together with the Mascarene Islands, Indian Ocean).

Keywords: Faunistic records, Hyrcania, Myriapoda, Near East, Taxonomy

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INTRODUCTION

Millipedes, or Diplopoda, are the largest class of Myriapoda, a group of land arthropods currently encompassing ca 11,000 described species from 2,000+ genera, 140+ families and 16 extant orders, and populating all continents except Antarctica (Enghoff et al., 2015). The bulk of millipede diversity is observed in tropical and subtropical countries, whereas temperate faunas are dominated by fewer orders of Diplopoda, i.e. the mostly Holarctic Glomerida, Julida and Callipodida. Diplopoda are largely meso- to hygrophilous, the detritivores that consume dead plant material and mostly inhabit forest litter and the uppermost soil, albeit the proportions of soil- and, especially, cave-dwellers are also considerable. The main and primary environment for millipedes seems to have always been the forest floor (Golovatch, 1994; Kime & Golovatch, 2000). The largely highly restricted dispersal abilities and the typically poor compensatory ecological capacities, when even one limiting factor cannot be compensated for by others, however favourable, result in millipede species distributions mostly being narrow, and local endemism profound. Thus, the world records of millipede local diversity, or faunules, are only ca 40 species in tropical forest nature reserves in central Amazonia, Brazil and southern Vietnam (Golovatch, 1997; Golovatch et al., 2011).

Taxonomic research on the diplopod fauna of Iran started with the pioneer paper by Humbert & de Saussure (1869) who described the first two species from the country. Further progress had been rather modest and sporadic until Enghoff & Moravvej (2005) compiled the first catalogue of Iranian Diplopoda and listed all faunistic records, both old and new. The catalogue concerned already 50 species. The latest checklist and review (Golovatch et al., 2022) culminated in altogether 55 species, 27 genera, 13 families and eight orders of millipedes being recorded from Iran. Of them, at least 33 species, but not a single higher taxon, have been noted as endemic or subendemic to Hyrcania. Presenting another review of step-by-step faunistic studies on the Diplopoda of Iran hardly makes sense, as all relevant information is contained below per species, both in terms of references and faunistic records. In addition, the distributions are

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assembled into gross chorotypes (see Table 1), and several species that are formally still absent from the fauna of Iran are pointed out as potential and most likely future records.

The Caucasus as a biogeographic realm of the Palaearctic subregion of the Holarctic has long been known as comprising two mesic biogeographic provinces, one, Colchis (= Colchida), in the west, stranding along the eastern and southeastern coasts of the Black Sea within Russia, Abkhazia, Georgia and Turkey, and the other, Hyrcania, along the southwestern and southern coasts both of the Republic of Azerbaijan and Iran. Both counterpart provinces support ancient meso- to hygrophytic woodlands (Wulff, 1944; Abdurakhmanov, 2017), the habitats preferred by Diplopoda. Both Colchis and Hyrcania are strongly separated by the montane and much more xeric Caucasus Minor uplands. Hardly surprising, it is Hyrcania that hosts most of Iran's millipede fauna and endemic species (Golovatch et al., 2022). In contrast, only one genus with two species appears to be endemic to southern and central Iran, well outside its Hyrcanian part.

The present contribution updates and refines the Iranian fauna of Diplopoda and, following Enghoff et al. (2015), it also provides the modern classification of all higher taxa and most of the estimates of their global diversity. Only subfamilies and subgenera have been omitted as being hardly too relevant (cf. Enghoff & Moravvej, 2005; Golovatch et al., 2022).

MATERIAL AND METHODS

The data presented below are derived from all relevant taxonomic and/or faunistic papers pertaining to the millipedes of Iran (see list of references). Two most recent synopses (Enghoff & Moravvej, 2005; Golovatch et al., 2022) served as the basics, whereas the detailed information for the species recorded from Iran has been documented based on original representative sources (Brolemann, 1922; Lohmander, 1932, 1936; Attems, 1927, 1951; Golovatch, 1981, 1983; Mauriès, 1982; Enghoff, 1984, 1990, 1995; Read, 1992; Reboleira et al., 2015; Vagalinski & Lazányi, 2018; Vagalinski, 2020; Vagalinski & Golovatch, 2021), which primarily include the original descriptions and reports of their distribution ranges. The classification and nomenclature are derived from the most recent global treatise on Diplopoda (Enghoff et al., 2015). The number of species, genera, families, suborders, and orders is indicated alongside the name of the primary (parent) taxon. The global statistics for the relevant taxa are specified in brackets.

RESULTS

Taxonomic hierarchy

Phylum: Arthropoda von Siebold, 1848

Subphylum: Myriapoda Latreille, 1802

Class Diplopoda Blainville in Gervais, 1844 – (8[16] orders, 13[140+] families, 27[2,000+] genera, ca 11,000 species).

Subclass Penicillata Latreille, 1831 – (1[1] order, 2[38] genera, 2[ca 150] species).

Order Polyxenida Verhoeff, 1934 – (2[3] families).

Family Lophoproctidae Silvestri, 1897 – (1[5] genera, 1[43] species).

Genus *Lophoproctus* Pocock, 1894 – (1[4] species).

Family Polyxenidae Lucas, 1840 – (1[22] genera, 1[ca 98] species).

Genus *Propolyxenus* Latreille, 1802/03 – (1[9] species).

Subclass Chilognatha Latreille, 1802/03 – (7[15] orders, 25[1962+] genera, >10,000 species).

Infraclass Pentazonia Brandt, 1833 – (1[3] orders, 2[ca 675] species).

Order Glomerida Leach, 1814 – (2[3] families, 3[34] genera, 4[300+] species).

Family Glomeridae Leach, 1815 – (2[28] genera, 2[ca 250] species).

Genus *Hyleoglomeris* Verhoeff, 1910 – (1[100+] species).

Genus *Trachysphaera* Heller, 1857 – (1[ca 30] species).

Family Glomeridellidae Cook, 1896 – (1[3] genus, 1[25] species).

Genus *Typhloglomeris* Verhoeff, 1898 – (1[ca 15] species).

Infraclass Helminthomorpha Pocock, 1887 – (12 orders, ca 9,000 species).

Subterclass Colobognatha Brandt, 1834 – (1[4] orders, 1[8] families, 1[240+] species).

Order Platydesmida de Saussure, 1860 – (1[2] families, 1[70+] species).

Family Androgathidae Cope, 1869 – (1[12] genera, 1[40+] species).

Genus *Fioria* Silvestri, 1898 – (1[4] species).

Subterclass Eugnatha Attems, 1898 – (3[3] superorders, > 8,700 species).

Superorder Nematophora – (2[3] orders).

Order Callipodida Pocock, 1894 – (1[3] suborders, 2[8] families, 2[36] genera & subgenera, 3[ca 140] species/subspecies).

Family Caspiopetalidae Lohmander, 1931 – (1[1] genus, 2[8] species).

Genus *Bollmania* Silvestri, 1896 – (2[8] species).

Family Schizopetalidae Verhoeff, 1909 – (1[10] genera, 1[53] species).

Genus *Eurygyrus* C.L. Koch, 1847 – (1[18] species).

Order Chordeumatida Pocock, 1894 – (1[4] suborders, 1[ca 50] families).

Suborder Craspedosomatidea Cook, 1895 – (1[3] families, 2[48] genera).

Family Anthroleucosomatidae Verhoeff, 1899 – (2[ca 25] genera, 2[70+] species).

Genus *Alloiopus* Attems, 1951 – (1[1] species).

Genus *Metamastigophorophyllon* Cauca, 1976 – (1[5] species).

Superorder Juliformia Attems, 1926 – (2[3] orders).

Order Spirostreptida Brandt, 1833 – (1[2] suborders).

Suborder Cambalidea Cook, 1895 – (1[5] families).

Family Cambalidae Bollman, 1893 – (1[ca 40] genera and 2[200+] species).

Genus *Chiraziulus* Mauriès, 1983 – (2[2] species).

Remarks. This is the only Palaearctic Cambalidea endemic to Iran. Originally proposed as a subgenus of *Nannolene* Bollman, 1887 (Mauriès, 1983).

Order Julida Brandt, 1833 – (2[5] superfamilies, 2[16] families).

Superfamily Blaniuloidea C. L. Koch, 1847 – (1[4] families).

Family Blaniulidae C. L. Koch, 1847 – (1[22] genera, 1[67] species).

Genus *Nopoiulus* Menge, 1851 – (3[11] species).

Superfamily Julioidea Leach, 1814 – (1[4] families).

Family Julidae Leach, 1814 – (10[ca 75] genera, 31[700+] species).

Genus *Brachyiulus* Berlese, 1884 – (1[ca 7] species).

Genus *Calyptophyllum* Brolemann, 1922 – (4[10] species).

Genus *Catamicrophyllum* Verhoeff, 1900 – (1[12] species).

Genus *Cylindroiulus* Verhoeff, 1894 – (5[ca 130] species)

Genus *Iraniulus* Attems, 1951 – (1[2] species).

Genus *Leptoiulus* Verhoeff, 1894 – (6[ca 77] species).

Genus *Ommatoiulus* Latzel, 1884 – (1[80+] species).

Genus *Omobrachiulus* Lohmander, 1936 – (1[ca 25] species).

Genus *Syriobrachiulus* Verhoeff, 1930 – (2[3] species).

Genus *Syrroiulus* Verhoeff, 1914 – (9[ca 15] species).

Superorder Merochaeta Cook, 1895 – (1[1] order, 2[27] families).

Order Polydesmida Leach, 1815 – (2[5] suborders, 2[27] families).

Suborder Strongylosomatidea Brölemann, 1916 – (1[1] family).

Family Paradoxosomatidae Daday, 1889 – (4[200+] genera, 9[1,000+] species).

Remarks. The largest family of Diplopoda mostly occurred in tropical or subtropical.

Genus *Lohmanderodesmus* Schubart, 1934 – (1[2] species).

Genus *Oxidus* Cook, 1911 – (1[5] species).

Genus *Strongylosoma* Brandt, 1833 – (3[12] species).

Genus *Tetrarthrosoma* Verhoeff, 1898 – (4[12] species[subspecies]).

Suborder Polydesmidea Pocock, 1887 – (1[4] superfamilies, 1[10] families).

Superfamily Polydesmoidea Leach, 1815 – (1[3] families).

Family Polydesmidae Leach, 1815 – (1[ca 30] genera, 2[270+] species)

Genus *Brachydesmus* Heller, 1858 – (2[ca 75] species).

DISCUSSION

Formally, the diplopod fauna of Iran presently contains 54 species from 27 genera, 13 families and eight orders (Table 1). The dominant group is by far the order Julida (29 species, 11 genera and two families), followed by 10 species, five genera and two families of Polydesmida. The remaining orders, families, genera and species are clearly subordinate in terms of diversity. The fauna can generally be described as rather poor, expectedly richer only due to the relatively numerous endemic or subendemic Hyrcanian species (33), especially in the julidan genera *Nopoiulus*, *Calypotphyllum*, *Leptoiulus* and *Syrroiulus*. The absence of higher diplopod taxa endemic or subendemic to Hyrcania is noteworthy, markedly contrasting the Colchidan fauna which, within Russia, Abkhazia and Georgia alone, is much richer and more diverse. Currently, it amounts to 130+ species, 40+ genera, 12 families and seven orders (e.g. Antić & Makarov, 2016; Golovatch et al., 2016; Evsyukov, 2016; Evsyukov et al., 2016, 2018, 2020, 2021; Short et al., 2020; Kokhia & Golovatch, 2020), including numerous species and several genera endemic to Colchis. That Iran, a very vast, but mostly quite arid territory, supports only a moderately rich millipede fauna is hardly surprising. The same concerns the predominance of Palaearctic elements.

Yet there is a remarkable exception represented by both known species of the genus *Chiraziulus*, definitely, an ancient relict and the only indigenous member of the suborder Cambalida, order Spirostreptida in the entire Near East. The present distribution pattern of this suborder is Nearctic (together with the Hawaiian Islands, Pacific Ocean) in the New World, but rather Oriental, both tropical and subtropical, in Indo-Australasia (together with the Mascarene Islands, Indian Ocean). Remarkably, the only fossil record of a cambalidean concerns the Oligocene of France (Shelley & Golovatch, 2011). Moreover, one of the species of *Chiraziulus* is the only troglobiont millipede to be reported from Iran.

Table 1. Fauna and chorology of the Diplopoda of Iran and Hyrcania.

Species	Chorotype	Species	Chorotype	Species	Chorotype
Polyxenida, Lophoproctidae		Julida, Blaniulidae		<i>Omobrachiulus caucasicus</i>	Ca
<i>Lophoproctus coecus</i>	cM	<i>Nopoiulus extremus</i>	H	<i>Syriobrachiulus golovatchi</i>	IE
Polyxenidae		<i>N. iranicus</i>	He	<i>S. iranicus</i>	IE
<i>Propolyxenus argentifer</i>	cM	<i>N. martensi</i>	H	<i>Syrioiulus astrabadensis</i>	He
Glomerida, Glomeridellidae		Julidae		<i>S. continentalis</i>	H
<i>Typhloglomeris martensi</i>	eM	<i>Brachiulus lusitanus</i>	A	<i>S. discolor</i>	He
Glomeridae		<i>Calyptophyllum biramum</i>	IE	<i>S. incarnatus</i>	He
<i>Hyleoglomeris lenkorana</i>	H	<i>C. furcatum</i>	IE	<i>S. lohmanderi</i>	He
<i>Trachysphaera costata</i>	EuMe	<i>C. integrum</i>	IE	<i>S. persicus</i>	He
Platydesmida, Andrognathidae		<i>C. obvolvatum</i>	IE	Polydesmida, Paradoxosomatidae	
<i>Fioria hyrcana</i>	H	<i>Catamicrophyllum tholicolepis</i>	IE	<i>*Lohmanderodesmus setiger</i>	IE
Callipodida, Caspiopetalidae		<i>*Cylindroiulus cf. besucheti</i>	H?	<i>Strongylosoma kordylamythrum</i>	Ca
<i>Bollmania gracilis</i>	EI	<i>C. bicolor</i>	Ca	<i>S. lenkoranum</i>	Ca
<i>B. nematogona</i>	EI	<i>C. crista</i>	He	<i>*S. uniseriale</i>	He
Schizopetalidae		<i>C. treptoflagellum</i>	II	<i>Oxidus gracilis</i>	A
<i>Eurygyrus phoeniceus</i>	ISe	<i>C. truncorum</i>	A	<i>Tetrarthrosoma broelemanni</i>	eM
Chordeumatida, Anthroleucosomatidae		<i>Iranulius fagorum</i>	H	<i>*T. maceratum</i>	IE
<i>Alloioopus solitarius</i>	H	<i>Leptoiulus anguiglossus</i>	He	<i>*T. persicum</i>	eM
<i>Metamastigophorophyllon martensi</i>	H	<i>L. arabistanus</i>	IE	<i>*T. syriacum</i>	eM
Spirostreptida, Cambalidae		<i>L. astrabadensis</i>	He	Polydesmidae	
<i>Chiraziulus kaiseri</i>	IE	<i>L. hastatus</i>	Ca	<i>Brachydesmus kalischewskyi</i>	Ca
<i>C. troglopersicus</i>	IE, T	<i>L. serpentinus</i>	EI	<i>B. pigmentatus</i>	H
		<i>Ommatoiulus caspius</i>	H		
Total: 54/27/13/9					

Chorotypes, from wider to increasingly narrower distributions: A – Anthropochoric introduction; EuMe – Euro-Mediterranean; eM – eastern Mediterranean (including the Near East); Ca – Caucasian to pan-Caucasian; ISe – subendemic to Iran beyond Hyrcania; IE – endemic to Iran beyond Hyrcania; H – pan-Hyrcanian; He – endemic to Iranian Hyrcania; T – troglobiont (Golovatch et al., 2022). Asterisk – an uncertain status (Enghoff & Moravvej, 2005).

Endemism in the Diplopoda fauna of Iran is expectedly overwhelming, amounting to ca 80% at the species level, but nearly absent at any higher rank. As noted earlier, *Chiraziulus* is the sole exception. Naturally, the above estimates are only provisional as the fauna is still far from fully assessed. Thus, seven species are still of uncertain status: *Cylindroiulus cf. besucheti*, *?Syrioiulus zarudnyi*, *Lohmanderodesmus setiger*, *Strongylosoma uniseriale*, *Tetrarthrosoma maceratum*, *T. persicum* and *T. syriacum*. These five latter paradoxosomatids may well be synonyms of other Iranian species (Enghoff & Moravvej, 2005). *Syrioiulus taliscius*, a species originally described from the Talysh Mountains within the Republic of Azerbaijan (Attems, 1927), has been erroneously quoted for the Iranian part of Hyrcania as well (Golovatch et al., 2022). However, *Syrioiulus armeniacus*, *S. taliscius* and *Leptoiulus meskhii*, like a few other millipedes so far conventionally referred to as endemic to the Hyrcanian part of the Republic of Azerbaijan alone, have been recorded so close to the borders of NW Iran that they could be listed herewith as potentially occurring in Iran as well.

The remaining species include three widespread anthropochores: *Brachiulus lusitanus*, *Cylindroiulus truncorum* and *Oxidus gracilis*, all definitely introductions. These may well be joined by *Nopoiulus kochii* (Gervais, 1847), a subcosmopolitan species very common and widespread in the Caucasus, but not yet

formally recorded from Iran (Golovatch & Enghoff, 1990). Quite expectedly, the closest ties of the Iranian diplopod fauna lie with the Republic of Azerbaijan, to a much lesser extent with Armenia or Iraq, this in particular being due to the numerous Hyrcanian elements shared. Together with several other species, as well as genera, families and orders, the millipede list of Iran can generally be considered as Caucasian, part of the eastern Mediterranean realm. Further taxonomic research in the Diplopoda of Iran will undoubtedly enrich and refine the faunal list presented herewith.

AUTHOR'S CONTRIBUTION

The author confirms that the entire work has been written by himself alone.

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AVAILABILITY OF DATA AND MATERIAL

The main sources for the published material are Enghoff & Moravvej (2005), Enghoff et al. (2015) and Golovatch et al. (2022).

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study only included a list of the arthropod material, and all required ethical guidelines for the treatment and use of animals were strictly adhered to in accordance with international, national, and institutional regulations. No human participants were involved in any studies conducted by the author for this article.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The author declares that there is no conflict of interest regarding the publication of this paper.

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تنوع بندپایان در ایران: رده هزارپایان (*Diplopoda* Blainville in Gervais, 1844)

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چکیده: در حال حاضر فون هزارپایان ایران به طور رسمی شامل ۵۴ گونه از ۲۷ جنس، ۱۳ خانواده و هشت راسته است که فهرست آنها بر اساس نام گذاری و برآورد تنوع ارایه شد. درجه اندمیسیم تا سطح گونه ها بسیار زیاد (حدود ۸۰٪) است، اما در آرایه های بالاتر تقریباً وجود ندارد. تنها آرایه نسبتاً قابل توجه، جنس *Chiraziulus* است که هر دو گونه آن بومی جنوب یا مرکز ایران هستند. به طور کلی، فون ایران را می توان به عنوان جزیی از فون قفقاز در نظر گرفت که بخشی از قلمرو مدیترانه شرقی است، در مقابل گونه های جنس *Chiraziulus* به وضوح نمایانگر یک گروه بسیار قدیمی و باقیمانده از زیرراسته *Cambalidea* هستند که در حال حاضر در منطقه نئارکتیک (همراه با جزایر هاوایی، اقیانوس آرام) در دنیای جدید انتشار دارند، اما تا زیادی در مناطق گرمسیری و نیمه گرمسیری خاورزمین، هند و استرالیا (همراه با جزایر ماسکارن، اقیانوس هند) نیز یافت می شوند.

واژگان کلیدی: سوابق فونستیک، هیرکانی، هزارپایان، خاور نزدیک