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An updated checklist of the millipedes of Iran (Diplopoda), with special emphasis on the fauna of Hyrcania, including noteworthy records of three species from its easternmost part

Современный контрольный список двупарноногих многоножек (Diplopoda) Ирана с особым вниманием к фауне Гиркании, включая примечательные находки трех видов в самой ее восточной части

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КЛЮЧЕВЫЕ СЛОВА: фаунистика, таксономия, распространение, иконография, реликтовый лес из *Parrotia* и *Carpinus*, провинция Голестан.

ABSTRACT. The fauna of Diplopoda of Iran is summarized, presently comprising 56 species from 27 genera, 13 families and eight orders. Special attention is paid to the fauna of Hyrcania (at least 33 species, largely endemic, but without any endemic genera), this being prompted by a small collection from a relict *Parrotia* and *Carpinus* forest patch in Golestan Province, Iran. It contains only three identifiable species: *Brachydesmus kalischewskyi* Lignau, 1915, very similar to morph D, *Nopoiulus martensi* Enghoff, 1984, and *Leptoiulus astrabadensis* Lohmander, 1932. All these basically Caucasian species are illustrated and currently represent the easternmost records in Hyrcania. The former species is polymorphous and pan-Caucasian in distribution, whereas the latter two are endemic to Hyrcania.

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РЕЗЮМЕ. Представлен новый контрольный список Diplopoda фауны Ирана, насчитывающий теперь 56 видов из 27 родов, 13 семейств и восьми отрядов. Особое внимание уделено фауне Гиркании (по меньшей мере 33 вида, большинство эндемичных, но без единого эндемичного рода) в связи с обработкой небольшой коллекции из участка реликтового леса из *Parrotia* и *Carpinus* в провинции Голестан (Иран). Сборы содержит лишь три определяемых вида: *Brachydesmus kalischewskyi* Lignau, 1915, очень похож на морфу D, *Nopoiulus martensi* Enghoff, 1984 и *Leptoiulus astrabadensis* Lohmander, 1932. Все эти три в целом кавказских вида снабжены фотографиями и в настоящее время представляют собой самые восточные находки в Гиркании. Первый из видов полиморфен и распространен по всему Кавказу, тогда как оба последних вида – эндемики Гиркании.

Introduction

The Caucasus is a vast, mostly mountainous region situated between the Black Sea and the Caspian Sea and mainly occupied by Armenia, Azerbaijan, Georgia, and parts of southern Russia and northwestern

Iran. It is home to the Caucasus Mountains, including the Greater Caucasus Mountain Range, or the Caucasus Major, which has historically been considered a natural barrier between Eastern Europe and western Asia. On the southern side, the Lesser Caucasus, or the Caucasus Minor, includes the Javakheti Plateau and grows into the Armenian highlands, part of which is located in Turkey (https://en.wikipedia.org/wiki/Caucasus).

The Caucasus region is divided into the North Caucasus and South Caucasus, although the Western Caucasus also exists as a distinct geographic space within the North Caucasus. The Caucasus Major in the north is mostly shared by Russia and Georgia, as well as the northernmost parts of Azerbaijan. The Caucasus Minor in the south is occupied by several independent states, mostly by Armenia, Azerbaijan, and Georgia, but also extending to parts of northeastern Turkey and northern Iran (e.g., Abdurakhmanov [2017]; https://en.wikipedia.org/wiki/Caucasus).

In spite of limited geography and mostly temperate climate, the diversity of natural landscapes, plant and animal species, and cultivated plants in the Caucasus is unusually high. For these reasons, the Caucasus has long been included in the list of global biodiversity hotspots. The proportion of endemic species of higher plants and terrestrial vertebrates varies between 15–30% for individual groups, according to different authors, with a vast majority of some taxonomic groups such as the poorly vagile terrestrial snails, wingless beetles etc. exceeding 80% [Abdurakhmanov, 2017].

Similarly, according to the most recent estimates, the millipede fauna of the Caucasus is known to comprise > 160 species, > 50 genera, 14 families, and eight orders. Endemism at the species level is overwhelming, amounting to > 85%, while as many as 25 millipede genera are endemic or subendemic to the Caucasus. All families and orders they belong to, however, are widely distributed at least across the Euro-Mediterranean Realm [Vagalinski, Golovatch, 2021].

The Caucasus comprises two main hygro- to mesophytic biogeographic provinces, the larger Colchidan, spanning along the eastern and southeastern coasts of the Black Sea in the west, and the smaller Hyrcanian, stretched along the southwestern and southern coasts of the Caspian Sea. Both are divided by the montane, mostly far more xerophytic Caucasus Minor (e.g., Wulff [1944]; Gulisashvili [1964]; Abdurakhmanov [2017]).

Hyrcania has long been acknowledged to host a very ancient, peculiar, relict and highly endemic biota (e.g., Wulff [1944]). The western part of the province lies in the Republic of Azerbaijan, while the remaining, southwestern and southern parts belong to Iran. The diplopod fauna of Iran presently comprises 56 species from 27 genera, 13 families and eight orders [Enghoff, Moravvej, 2005; Reboleira *et al*., 2015; Short, 2015; Antiæ, Makarov, 2016; Golovatch *et al*., 2015, 2016; Vagalinski, Lazányi, 2018; Short *et al*., 2020; Vagalinski, 2020; Vagalinski, Golovatch, 2021], with >80% species and only one genus, *Chiraziulus* Mauriès, 1982, being confined to the country. At least 33 species, 17 genera, 11 families and six orders appear to occur in Hyrcania, with most (21) species, but none of the higher taxa, being endemic or subendemic to the Hyrcanian biogeographic province (Table). At present, perhaps the most widespread subendemic Hyrcanian diplopod species seems to be *Brachydesmus pigmentifer* Attems, 1951, which ranges from the Talysh Mountains and lowland Hyrcania within the Republic of Azerbaijan, through the Elburs and Zagros mountains in Iran, to the western Kopetdagh Mountains, Turkmenistan in the east [Golovatch *et al*., 2016].

The present contribution puts on record the identifiable part of a small collection of Diplopoda from Iran's Golestan Province, the easternmost Hyrcania, amassed in 2019 and 2020. Altogether, the collection contained five species, of which only three could firmly be identified because the samples comprised male material. The remaining two were represented by females and/or juveniles alone, this making their identification only provisional.

Material and methods

The material underlying the present contribution, all stored in 75% ethanol, has been fully donated to the collection of the Zoological Museum of the Moscow State University (ZMUM), Russia. Pictures were taken with a Canon EOS 5D digital camera and stacked using Zerene Stacker software.

The Shast-klateh *Parrotia* & *Carpinus* Forest Dr. Bahramnia near the city of Gorgan, Golestan Province, Iran represents an experimental plot of the Experimental and Educational Forest of Gorgan University of Agricultural Sciences and Natural Resources, where, among other subjects and objects, soils and soil fauna are being studied [Izadi *et al*., 2017]. Collections of soil macrofauna effectuated there by hand before 2019 also contained Diplopoda, albeit closer unidentified [Izadi *et al*., 2017].

Taxonomy and faunistics

Order Polydesmida

Family **Polydesmidae**

Brachydesmus kalischewskyi Lignau, 1915

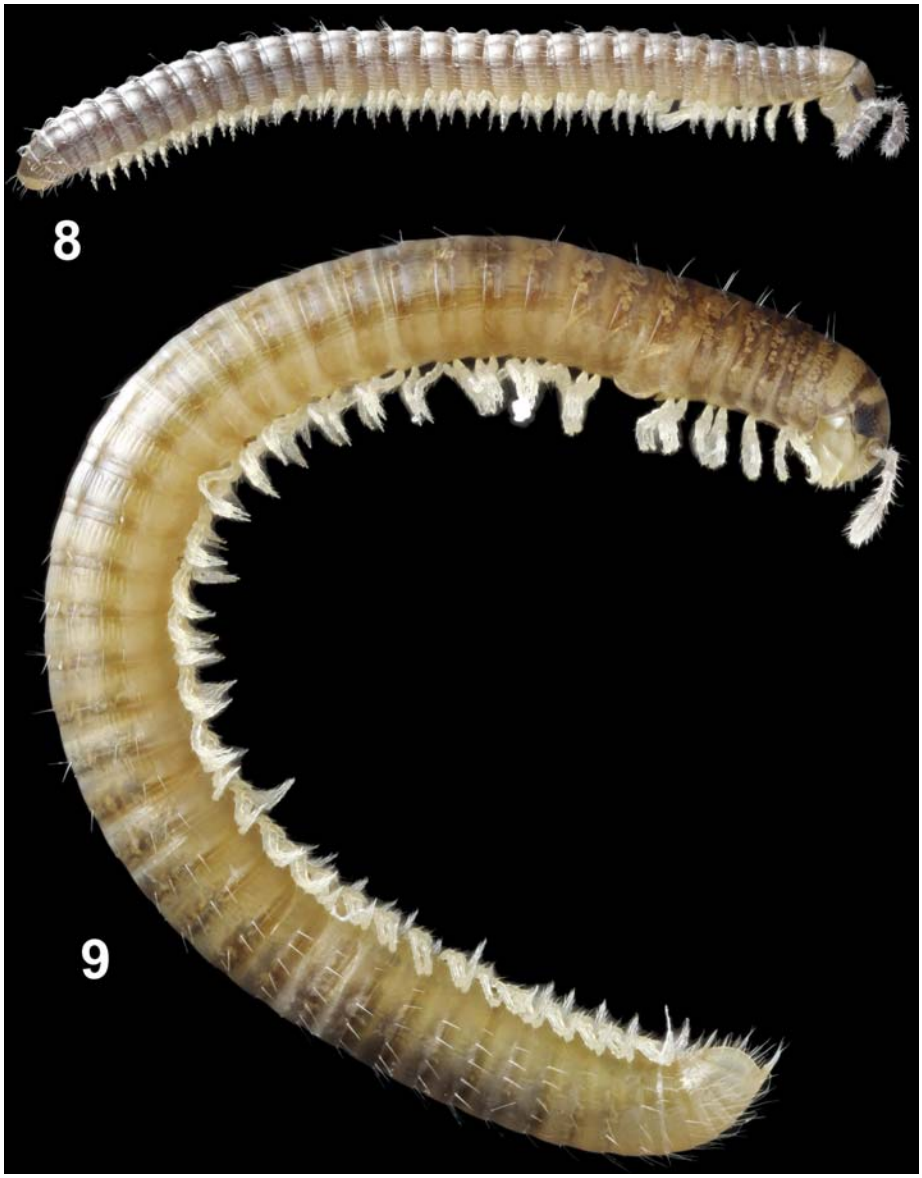
Figs 1–7.

MATERIAL. 1 ♀ (ZMUM), Iran, Golestan Prov., Shast-klateh *Parrotia persica* & *Carpinus betulus* Forest Dr. Bahramnia, N36° 46′30″, E54°22′30″, 450 m a.s.l., leaf litter, 20.IV.2019; 15 juv. (ZMUM), same place, 22.X.2019; 1 ♂, 1 ♀ (ZMUM), same place, 9.II.2020; 5 ♀♀ (ZMUM), same place, 19.II.2020 (ZMUM), all M. Izadi leg.

REMARKS. A very common, polymorphous and widespread pan-Caucasian species [Golovatch *et al*., 2016]. The above new sample from Iran quite vividly resembles morph D which is typical of Hyrcania and the Talysh Mountains within the Republic of Azerbaijan. The species, albeit without morph identifications, has been encountered in the adjacent parts of Turkey and Iran [Golovatch *et al*., 2016], more specifically, southeast to the East Azerbaijan Province of Iran [Enghoff, Moravvej, 2005; Golovatch *et al*., 2016].

Figs 1–7. *Brachydesmus kalischewskyi* Lignau, 1915, ♂ ca 10 mm long, very similar to morph D. 1–3 — habitus, dorsal, ventral and lateral views, respectively; 4–7 — left gonopod, anteromesal, anterior, posterior and lateral views, respectively. Photographs by K.V. Makarov, taken not to scale.

Рис. 1–7. *Brachydesmus kalischewskyi* Lignau, 1915, ♂ около 10 мм в длину, очень близкий к морфе D. 1–3 — общий вид, соответственно сверху, снизу и сбоку; 4–7 — левый гонопод, соответственно одновременно спереди и изнутри, изнутри, сзади и сбоку. Фотографии К.В. Макарова, снято без масштаба.



Figs 8, 9. Habitus of *Nopoiulus martensi* Enghoff, 1984 (8, ♂) and *Leptoiulus astrabadensis* Lohmander, 1932 (9, ♂), lateral views. Photographs by K.V. Makarov, taken not to scale.

Рис. 8, 9. *Nopoiulus martensi* Enghoff, 1984 (8, ♂) и *Leptoiulus astrabadensis* Lohmander, 1932 (9, ♂), сбоку. Фотографии К.В. Макарова, снято без масштаба.

The morph from the Golestan Province slightly differs in the somewhat less strongly rounded shapes of some anterior paraterga in dorsal view (Figs 1–3) and in the particularly slender and long apical hook **e** of the gonopodal telopodite (Figs 4–7).

Order Julida

Family **Blaniulidae**

Nopoiulus martensi Enghoff, 1984

Fig. 6.

MATERIAL. 1 ♀ (ZMUM), Iran, Golestan Prov., Shast-klateh *Parrotia persica* & *Carpinus betulus* Forest Dr. Bahramnia, N36° 46′30″, E54°22′30″, 450 m a.s.l., leaf litter, 20.IV.2019; 1 ♀ (ZMUM), same place, 19.II.2020; 1 ♀ (ZMUM), same place, 22.X. 2019; 1 ♂, 1 ♀ (ZMUM), same place, 21.XII,2019; 1 ♀ (ZMUM), same place, 20.IV.2019, all M. Izadi leg.

REMARKS. This species is endemic to Hyrcania within both the Republic of Azerbaijan and Iran (Enghoff, 1984, 1990), previously recorded east to Mazandaran [Enghoff, Moravvej, 2005].

Family **Julidae**

Leptoiulus astrabadensis Lohmander, 1932

Fig. 7.

MATERIAL. 1 juv. (ZMUM), Iran, Golestan Prov., Shast-klateh *Parrotia persica* & *Carpinus betulus* Forest Dr. Bahramnia, N36°46′30″, E54°22′30″, 450 m a.s.l., leaf litter, 22.X.2019; 1 ♂, 1 ♀, 3 juv. (ZMUM), same place, 22.X.2019; 1 ♂, 1 ♀ (ZMUM), same place, 19.II.2019; 1 ♂, 1 ♀ (ZMUM), same place, 21.XII.2019, all M. Izadi leg.

REMARK. This species is endemic to Hyrcania within Iran. As it has previously been described and remains known

Table. Fauna and chorology of the Diplopoda of Iran and Hyrcania.
Таблица. Фауна и хорология Diplopoda Ирана и Гиркании.

Species	Chorotype	Species	Chorotype	Species	Chorotype
Polyxenida Lophoproctidae		**Julida** Blaniulidae		*Omobrachyiulus caucasicus* (Karsch, 1881)	Ca
Lophoproctus coecus Pocock, 1894	eM	*Nopoiulus extremus* Enghoff, 1984	H	*Syriobrachyiulus golovatchi* Vagalinski et Lazányi, 2018	IE
Polyxenidae		*N. iranicus* Enghoff, 1984	He	*S. iranicus* (Golovatch, 1983)	IE
Propolyxenus argentifer (Verhoeff, 1921)	eM	*N. martensi* Enghoff, 1984	H	*Syrioiulus astrabadensis* (Lohmander, 1932)	He
Glomerida Glomeridellidae		Julidae		*S. continentalis* (Attems, 1903)	H
Typhloglomeris martensi (Golovatch, 1981)	eM	*Brachyiulus lusitanus* Verhoeff, 1898	A	*S. discolor* (Lohmander, 1932)	He
Glomeridae		*Calyptophyllum biramum* Attems, 1951	IE	*S. incarnatus* (Lohmander, 1932)	He
Hyleoglomeris lenkorana (Golovatch, 1989)	H	*C. furcatum* Enghoff, 1995	IE	*S. lohmanderi* Vagalinski, 2020	He
Trachysphaera costata (Waga, 1857)	EuMe	*C. integrum* Brolemann, 1922	IE	*S. persicus* (Golovatch, 1983)	He
Platydesmida Andrognathidae		*C. obvolvatum* Brolemann, 1922	IE	*S. taliscius* (Attems, 1927)	H
Fioria hyrcana Golovatch, 1980	H	*Catamicrophyllum tholicolepis* Enghoff, 1995	IE	**Polydesmida** Paradoxosomatidae	
Callipodida Caspiopetalidae		*Cylindroiulus* cf. *besucheti* Strasser, 1975	H?	*Lohmanderodesmus setiger* (Attems, 1951)	IE
Bollmania gracilis Golovatch, 1983	EI	*C. bicolor* Lohmander, 1932	Ca	*Strongylosoma kordylamythrum* Attems, 1898	Ca
B. nematogona (Attems, 1951)	EI	*C. crista* Read, 1992	He	*S. lenkoranum* Attems, 1898	Ca
Schizopetalidae		*C. treptoflagellum* Read, 1992	H	*S. uniseriale* Attems, 1951	He
Eurygyrus phoeniceus (Verhoeff, 1900)	ISe	*C. truncorum* (Silvestri, 1896)	A	*Oxidus gracilis* (C.L. Koch, 1847)	A
Chordeumatida Anthroleucosomatidae		*Iraniulus fagorum* (Attems, 1951)	H	*Tetrarthrosoma broelemanni* (Verhoeff, 1940)	eM
Alloiopus solitarius Attems, 1951	H	*Leptoiulus anguiglossus* Lohmander, 1932	He	*T. maceratum* (Attems, 1951)	IE
Metamastigophoro-phyllon martensi (Mauriès, 1982)	H	*L. arabistanus* Lohmander, 1932	IE	*T. persicum* (Humbert et de Saussure, 1869)	eM
Spirostreptida Cambalidae		*L. astrabadensis* Lohmander, 1932	He	*T. syriacum* (Humbert et de Saussure, 1869)	eM
Chiraziulus kaiseri (Mauriès, 1982)	IE	*L. hastatus* Lohmander, 1932	Ca	Polydesmidae	
C. troglopersicus Reboleira, Malek Hosseini, Sadeghi et Enghoff, 2015	IE, T	*L. serpentinus* Lohmander, 1932	EI	*Brachydesmus kalischewskyi* Lignau, 1915	Ca
		Ommatoiulus caspius (Lohmander, 1928)	H	*B. pigmentifer* Attems, 1951	H
Total: 56/27/13/8					

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.

exactly from near Gorgan (formerly Asterabad) [Lohmander, 1932], the above samples represent topotypes.

Conclusion

The above records actually represent the easternmost localities for all three species above. In addition, further two species contained in the samples, unfortunately only females and/or juveniles, could be identified but provisionally: *Omobrachyiulus caucasicus* (Karsch, 1881), a pan-Caucasian species (Table) already recorded from Hyrcania both within the Republic of Azerbaijan and Iran [Vagalinski, Golovatch, 2021], and a different *Nopoiulus* sp. Only additional, male-containing material could allow for their definitive identifications to be clarified.

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Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: No ethical issues were raised during our research.

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