



New records of heterostigmatic mites (Acari: Heterostigmata) from dry rice cultivation of Gorgan, northern Iran

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ABSTRACT. Gorgan, is a city in northern Iran where its moderate and humid climate and fertile soil provides an appropriate condition for various arthropods and crops. Although, species diversity is relatively lower in agricultural systems than pristine ecosystems, several soil mite populations are successfully adapted to both tilled and untilled lands. Following a faunistic study of heterostigmatic mites (Acari: Prostigmata: Heterostigmata) in dry rice cultivations in some areas of Gorgan, eight species from six genera of five families were collected and identified. For the first time we report six species for Iranian arthropod fauna as well as several new host associations. Finally, we reviewed the world distribution of the recovered mites and further provided a key to Heterostigmata of dry rice cultivations in Gorgan city.

Key words: Mite, insect, soil, crop, phoresy, Iran

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INTRODUCTION

Rice is cultivated in various systems with diverse ecosystems in Iran and is an important crop in food security of millions of people. Gorgan, a city located along the southern Caspian Sea shoreline and north of the Alborz Mountains, represents moderate and humid climate and fertile soils, and is a key region for rice cultivation in Iran (Jaiswal et al., 2016; Razzaghi et al., 2020; Rahiminejad & Hajiqanbar, 2020). Reduction in precipitation in the last few decades has modified the rice cultivation system from water logging (paddy-soil) into dry system in some parts of northern Iran (Ghorbaniminaei et al., 2019; Razzaghi et al., 2020). Since ecosystems are highly complex with network of interdependencies and interactions among different species and their habitats, changing in climate factors affect natural flora and fauna. Therefore, mites with important role in this intricate ecological system are highly affected by ecological dynamics (Okabe et al., 2012; Gwiazdowicz, 2021). Heterostigmatic mites (Acari:

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Prostigmata) are classified in eight Superfamilies and include more than 2000 described species (Walter et al., 2009; Zhang et al., 2011). It seems fungivory and herbivory are the most feeding strategies in the subclass of mites. They also exhibit various symbiotic associations with other animals (especially insects) such as kleptoparasitism, parasitism, parasitoidism, predatory and phoresy, with the latter being probably derived from the free-living fungivorous ancestors (Kaliszewski et al., 1995; Walter et al., 2009).

Possibly the new cultivation method would prepare more appropriate conditions for mites, due to their terrestrial locomotion behaviors (Walter et al., 2009). Since mite fauna in dry rice cultivations and their vicinities have not been studied so far, and given that several heterostigmatic species such as *Steneotorsonemus spiniki* Smiley, are pest of rice, (Kayal et al., 2021), this study has been conducted to determine the heterostigmatic mite fauna in dry rice cultivations of Gorgan.

MATERIAL AND METHODS

The mites were collected using three sampling methods. Rice sheaths were collected directly from the field and examined under stereomicroscope. Also, soil dwelling mites were extracted from collected soil samples using Berlese funnels. Eventually, for phoretic mites, the host insect specimens were captured using light trap, in the dry rice cultivation in vicinity of Gorgan. Mite specimens were collected from leaves and sheaths of rice, separated from soil particles or extracted from their host insects under a stereomicroscope (Olympus® SZ, Tokyo, Japan). Collected specimens were transferred to a clearing solution comprising of a mixture of lactophenol and Nesbitt's fluids (1:1 ratio), and subsequently mounted in Hoyer's medium. Microscopic slides were studied using an Olympus® BX51 phase-contrast microscope. The taxonomical hierarchy follows that of Kaliszewski et al. (1995) and Khaustov (2004). All obtained specimens were adult female and collected by the first and third authors. All the materials are deposited in the Arthropods Collection, Acari Section, Department of Plant Protection, Faculty of Plant Production, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran.

NOTES ON THE RESULTS

Mites are given in alphabetical order based on superfamilies followed by families, genera and species.

World distribution - Country(ies), host(s) [as given in source publication], source publication(s).

Material examined - All available data about species, host(s), sampling method(s) and location(s).

Remarks - Any relevant information [new record for fauna of Iran and/or new host record(s)].

RESULTS

Cohort Heterostigmata

Superfamily Dolichocyboidea Mahunka, 1970

Family Dolichocybidae Mahunka, 1970

Genus *Dolichomotes* Smiley, 1967

Type species: *Dolichomotes navei* Smiley, 1967, by original designation.

Dolichomotes crossi Rack, 1973

World distribution. United States—21 females were collected under bark of walnut trees (*Juglans* sp.) (Rack, 1973).

Material examined. 1♀, Iran, Golestan province, Gorgan, Nodijeh village (36.49°N, 54.16°E, 28 m a.s.l.), extracted from soil, litter and rotten leaves sample under Oak trees (*Quercus* sp.) in vicinity of dry rice cultivation, 1.vi.2020, leg.: V. Rahiminejad.

Remarks. *Dolichomotes crossi* has only been recorded from Nearctic region (Rack 1973), so, this is the first record of the species from Palaearctic region. Previously, only one species of this genus, *D. sinuspersicus* has been recorded from Iran, Hormozgan province (Mortazavi et al., 2015).

Superfamily Pygmephoroidae Cross, 1965

Family Pygmephoridae Cross, 1965

Genus *Pediculaster* Vitzthum, 1931

Type species: *Pygmephorus mesembrinae* Canestrini, 1881, by original designation.

Pediculaster dudichi Mahunka, 1970

World distribution. Hungary – phoretomorphic females were collected from soil samples (Mahunka, 1970).

Material examined. 3♀♀, Iran, Golestan province, Gorgan, Nodijeh village (36.90°N, 54.52°E, 97 m a.s.l.), extracted from a soil sample in dry rice cultivation, 19.vii.2020; 2♀♀, Gorgan, Ali-Abad Kenaar-Shahr village (36.90°N, 54.52°E, 97 m a.s.l.), 12.vii.2020, leg.: V. Rahiminejad.

Remarks. This is a first record of *P. dudichi* and the tenth *Pediculaster* representative for Iranian mite fauna (Seyedein et al., 2021).

Family Neopygmephoridae Cross, 1965

Genus *Allopygmephorus* Cross, 1965

Type species: *Pygmephorus matthesi* Krczal, 1959, by original designation.

Allopygmephorus heterodactylus Mahunka, 1973

World distribution. Ghana – collected from undetermined beetle (Mahunka, 1973).

Material examined. 2♀♀, Iran, Golestan province, Gorgan, Ali-Abad Kenaar-Shahr village (36.90°N, 54.52°E, 97 m a.s.l.), associated with *Cercyon* sp. (Col.: Hydrophyllidae), captured by a light trap, 30.vii.2020, leg.: V. Rahiminejad.

Remarks. This is the first record of phoretic association between this mite and the host beetle of the genus *Cercyon* Leach, 1817. Also, this species is recorded for the first time from Asia.

Allopygmephorus matthesi Krczal, 1959

World distribution. Germany – associated with several beetles, *Berosus luridus* L., *Coelostoma orbiculare* F., *Enochrus quadripunctatus* Herbst, *Helochaeres griseus* F., *H. lividus* Forster, *Hydrobius fuscipes* L., *Hydrophilus caraboides* F., *Philydrus melanocephalus* F. (Hydrophilidae), *Heterocerus marginatus* F. (Heteroceridae), *Dryops auriculatus* Geoffroy (Dryopidae). Tanzania – collected from undetermined beetle (Krczal, 1959; Mahunka, 1973).

Material examined. More than 45♀♀, Iran, Golestan province, Gorgan, Sorkhan-Kkalateh village (36.99°N, 54.56°E, 105 m a.s.l.), associated with *Xyleborus* sp. (Col.: Curculionidae: Scolytinae), 8.vi.2020, leg.: V. Rahiminejad.

Remarks. This is the first record of phoretic association between the mite and the host genus *Xyleborus*. Also, this species is recorded for the first time from Asia.

Allopygmephorus orientalis Mahunka and Mahunka, 1988

World distribution. Malaysia – extracted from soil samples (Mahunka & Mahunka, 1988).

Material examined. 2♀♀, Iran, Golestan province, Gorgan, Nodijeh village (36.49°N, 54.16°E, 28 m a.s.l.), extracted from a soil sample in the vicinity of dry rice cultivation, 21.vi.2020; 1♀, Gorban, Sorkhan–Kalateh village (36.99°N, 54.56°E, 105 m a.s.l.), 27.vii.2020, leg.: V. Rahiminejhad.

Remarks. The species is a new record for mite fauna of Iran.

Family Microdispidae Cross, 1965

Genus *Premicrodispus* Cross, 1965

Type species: *Microdispus* (*Premicrodispus*) *chandleri* Cross, 1965, by original designation.

Three subgenera, *Premicrodispus* Cross, 1965, *Premicrodispulus* Khaustov & Chydyrov, 2010,

Premicrodispoides Khaustov & Maslov, 2013, and about 31 species constitute the cosmopolitan genus, *Premicrodispus* (Khaustov & Minor, 2020). Recently, Iranian *Premicrodispus* mites have been reviewed and a new species described in association with *Lucanus ibericus* Motschulsky, 1845 (Col.: Lucanidae) (Seyedein et al., 2020)

Premicrodispus stenops (Mahunka, 1969)

World distribution. Previously, *P. stenops* was extracted from Mongolian soil samples (Mahunka, 1969).

Material examined. 2♀♀, Iran, Golestan province, Sorkhan–Kalateh village (36.99°N, 54.56°E, 105 m a.s.l.), extracted from a soil sample under Poplar trees (*Populus* sp.) in vicinity of dry rice cultivation, 6.viii.2020, leg.: V. Rahiminejhad.

Remarks. The species is a new record for mite fauna of Iran.

Genus *Paramicrodispus* Khaustov, 2009

Type species: *Brennandania crenulata* Savulkina, 1978

Paramicrodispus Crenulatus (Savulkina, 1978)

World distribution. Bulgaria—in the nest of a small mammal (Savulkina, 1978). Ukraine (Crimea)—beneath elytra of a carabid beetle *Pterostichus niger* (Schaller, 1783), in a rotten log of *Fagus orientalis* (Khaustov, 2009). Iran—in association with *Lucanus ibericus* Motschulsky, 1845 (Col.: Lucanidae) (Hajiqanbar et al., 2012).

Material examined. 8♀♀, Iran, Golestan province, Gorgan, Sorkhan–Kalateh village (36.99°N, 54.56°E, 105 m a.s.l.), extracted from a soil sample in vicinity of dry rice cultivation, 14.viii.2020, leg.: V. Rahiminejhad.

Remarks. The species is recorded for the first time from soil.

Family Scutacaridae Oudemans, 1916

Genus *Scutacarus* Gros, 1845

Type species: *Scutacarus femoris* Gros, 1845

Scutacarus sphaeroideus Karafiati, 1959

World distribution. This species has world-wide distribution and inhabits soils shorelines (Khaustov, 2008) and has been found to be phoretic on ants, beetles (Staphylinidae, Heteroceridae) and small mammals (Cricetidae, Muridae) (Baumann & Ferragut, 2018). This species has been collected several

times in Iran from soil samples and associated with hydrophilid beetles (Col.: Hydrophilidae) and *Dryops* sp. (Col.: Dryopidae) (Hajiqanbar, 2008; Tajodin, 2013; Seyedein et al., 2020).

Material examined. 50♀♀, Iran, Golestan province, Gorgan, Nodijeh village (36.49°N, 54.16°E, 28 m a.s.l.), 2♀♀, Sorkhan-Kalateh village (36.99°N, 54.56°E, 105 m a.s.l.) and Ali-Abad Kenaar-Shahr village (36.90°N, 54.52°E, 97 m a.s.l.), extracted from soil samples, vi–viii.2019, leg.: V. Rahiminejad..

Key to the genera and species of Heterostigmata recorded from dry rice cultivation in Gorgan, northern Iran

1. Tarsus I with paired claws; trochanters of legs I, II, IV, and usually III lacking setae; females lacking the stigmata and associated tracheae (Superfamily Dolichocyboidea; Family Dolichocybidae). *Dolichomotes crossi* Rack, 1973
- Tarsus I without/with a single claw; trochanters of legs I–IV usually with a seta each; females with a pair of stigmata and associated tracheae anterolaterally on prodorsum (Superfamily Pygmephoridae). 2
2. Prodorsum of females not covered posteriorly by tergite C and usually with 3 pairs of setiform setae (v_1 and usually v_2 present); coxisternal plates I–II together with 4–6 pairs of setae; femur I usually with 4 setae (Family Pygmephoridae). *Pediculaster dudichi* Mahunka, 1970
- Prodorsum of females usually covered to some extent by tergite C and with 1–2 pairs of setiform setae (v_1 and sometimes v_2 absent); coxisternal plates I–II together with maximum of 4 pairs of setae. Femur I with 3 setae. 3
3. Prodorsum with 1 pairs of setiform setae (Family Microdispidae). 4
- Prodorsum usually with 2 pairs of setiform setae. 5
4. Posterior margin of posterior sternal plate with three large lobes (tripartite); eupathidium *ft'* present on tibiotarsus I (Genus *Premicrodispus*) *P. stenops* (Mahunka, 1969)
- Posterior margin of posterior sternal plate without lobe; eupathidium *ft'* absent on tibiotarsus I (Genus *Paramicrodispus*) *P. crenulatus* (Savulkina, 1978)
5. Tergite C expansive, entirely covering prodorsum, forming a roof over gnathosoma; setiform setae of prodorsum usually inconspicuous and often difficult to discern. Distance between insertions of legs II–III usually similar to that between legs III–IV (Family Scutacaridae). *Scutacarus sphaeroideus* Karafiati, 1959
- Tergite C not covering entire prodorsum and gnathosoma; setiform setae of prodorsum usually often conspicuous; distance between insertions of legs II–III usually two times longer than the distance between legs III–IV (Family Neopygmephoridae; Genus *Allopygmephorus*). 6
6. Claws on tarsus II and III symmetric. *A. matthesi* Kraczal, 1959
- Claws on tarsus II and III asymmetric. 7
7. Seta *f* more than three times longer than *e*. *A. orientalis* Mahunka & Mahunka, 1988
- Seta *f* less than two and half times longer than *e*. *A. heterodactylus* Mahunka, 1973

DISCUSSION

Considering the six new recorded species in the course of present study, the number of *Dolichomotes*, *Pediculaster*, *Allopygmephorus* and *Premicrodispus* genera representatives of Iran reached to two, six, six and 13 species, respectively (Table 1). Golestan province, compared to the other regions of Iran, have had a conspicuous role introducing new records and species of Heterostigmata. Besides more than 40 new records for Iranian heterostigmatic mite fauna, three genera and 20 species have been described from Golestan province, so far (Rahiminejad et al., 2020a, 2020b; Rahiminejad & Hajiqanbar, 2020; Seyedein et al., 2020, 2021). It is recommendable that further research on these mites in various ecosystems gives a better understanding of various aspect of their life.

Table 1. All Iranian species of the genera *Dolichomotes*, *Pediculaster*, *Allopygmephorus* and *Premicrodispus*.

Genera & species	References
<i>Dolichomotes</i> Smiley, 1967	Mortazavi et al., 2015
<i>D. sinuspersicus</i> Mortazavi & Hajiqaanbar, 2015	Present study
<i>D. crossi</i> Rack, 1973	
<i>Pediculaster</i> Vitzthum, 1931	Filekesh et al., 2014
<i>P. manicatus</i> (Berlese, 1904)	Rahiminejad & Hajiqaanbar, 2020
<i>P. pseudomanicatus</i> Camerik, 2001	Seyedein et al., 2021
<i>P. mesembrinae</i> (Canestrini, 1881)	Present study
<i>P. camerikae</i> Khaustov, 2008	
<i>P. absentia</i> Rahiminejad & Seyedein, 2021	
<i>P. dudichi</i> Mahunka, 1970	
<i>Allopygmephorus</i> Cross, 1965	Khaustov & Hajiqaanbar, 2006
<i>A. persicus</i> Khaustov & Hajiqaanbar, 2006	Navabi et al., 2018
<i>A. spinisetus</i> Khaustov & Sazhnev, 2016	Present study
<i>A. punctatus</i> Khaustov & Sazhnev, 2016	
<i>A. heterodactylus</i> Mahunka, 1973	
<i>A. matthesi</i> Krczal, 1959	
<i>A. orientalis</i> Mahunka & Mahunka, 1988	
<i>Premicrodispus</i> Cross, 1965	Hajiqaanbar & Sobhi, 2018
<i>P. acuitisetus</i> Khaustov, 2009	Rahiminejad et al., 2020a, 2020b
<i>P. rackae</i> Khaustov, 2006	Seyedein et al., 2020
<i>P. turkmenus</i> Badoodam & Hajiqaanbar, 2015	Present study
<i>P. spinosus</i> Hosseininaveh & Hajiqaanbar, 2015	
<i>P. paramaevi</i> Hosseininaveh & Hajiqaanbar, 2015	
<i>P. longicaudus</i> Khaustov, 2006	
<i>P. akermanae</i> (Sevastianov & Al Douri, 1988)	
<i>P. krczali</i> Khaustov, 2006	
<i>P. lineatus</i> (Mahunka, 1986)	
<i>P. brevisetus</i> Khaustov, 2006	
<i>P. gorganiensis</i> Rahiminejad & Seyedein, 2020	
<i>P. montanus</i> Khaustov, 2006	
<i>P. stenops</i> (Mahunka, 1969)	

AUTHOR'S CONTRIBUTION

The authors confirm contribution in the paper as follows: V.R.: Collected, sorted and prepared the specimens and prepared the manuscript. M.Y.: Edited the first version of the manuscript. S.Z.: Collected the specimens. All authors read and approved the final contents of the manuscript.

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AVAILABILITY OF DATA AND MATERIAL

Not applicable.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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گزارش‌های جدید از کنه‌های هترواستیگما (Acari: Heterostimatina) در برنج خشکه‌کاری در گرگان، شمال ایران

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چکیده: گرگان، شهری در شمال ایران، با آب و هوای مرطوب و معتدل و خاک حاصلخیز، محیط بسیار مناسبی را برای گونه‌های مختلف بندپایان و همچنین محصولات کشاورزی فراهم کرده‌است. اگرچه تنوع گونه‌ای در محیط‌های کشاورزی بسیار کمتر از اکوسیستم‌های بکر است، تعدادی از جمعیت‌های کنه‌های خاک‌زی، سازگاری خوبی با زمین‌های خاک‌ورزی شده و نشده پیدا کرده‌اند. طی یک مطالعه فونستیک بر روی کنه‌های هترواستیگما (Acari: Prostigmata: Heterostigmatina) در برنج خشکه‌کاری در برخی مناطق گرگان، هشت گونه از شش جنس متعلق به پنج خانواده جمع‌آوری و شناسایی شد. در این مقاله، شش گونه جدید برای فون بندپایان ایران همراه با تعدادی ارتباط میزبانی جدید گزارش می‌شود. در پایان، پراکنش جهانی گونه‌های یافت شده بررسی و کلیدی برای کنه‌های هترواستیگما در کشت‌های خشکه برنج در شهر گرگان ارائه شد.

واژگان کلیدی: کنه، حشره، خاک، محصولات کشاورزی، همسفری، ایران