New records of heterostigmatic mites (Acari: Heterostigmatina) 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: Heterostigmatina) 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 Heterostigmatina of dry rice cultivations in Gorgan city.

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

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 (Ghorbanimimaei 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: Heterostigmatina) are an interesting group in the context of dry rice cultivations in Gorgan city.
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. The 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 spinki 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. Rahiminejhad.
Remarks. *Dolichomotes crossi* has only been recorded from Nearctic region (Rack 1973), so, this is the first record of the species from Palaeartic region. Previously, only one species of this genus, *D. sinusupersicus* 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).


**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* Kraczal, 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.: Hydrophilidae), captured by a light trap, 30.vii.2020, leg.: V. Rahiminejhad.

**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* Kraczal, 1959


**Material examined.** More than 45♀♀, Iran, Colestan 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. Rahiminejhad.

**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)
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 Pygmeophoridae). ........................................ 2

2. Prodorsum of females not covered posteriorly by tergite C and usually with 3 pairs of setiform setae (v1 and usually v2 present); coxisternal plates I–II together with 4–6 pairs of setae; femur I usually with 4 setae (Family Pygmeophoridae). ........................................................................................................ Pediculaster dudichi Mahunka, 1970
   – Prodorsum of females usually covered to some extent by tergite C and with 1–2 pairs of setiform setae (v1 and sometimes v2 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 f’t present on tibiotarsus I (Genus Premicrodispus) ................................................................................................................................. P. stenops (Mahunka, 1969)
   – Posterior margin of posterior sternal plate without lobe; eupathidium f’t 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 Neopygmeophoridae; Genus Allopygmephorus). ................................................................................................................................. 6

6. Claws on tarsus II and III symmetric. ................................................................................................................................. A. matthesi Kranzal, 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 Heterostigmatina. 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*.

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


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

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چکیده: گرگان، شهری در شمال ایران، با آب و هوای مرطب و معتدل و خاک حاصلخیز، محیط بسیار مناسب را برای گونه‌های مختلف بندی‌بان و همچنین محصولات کشاورزی فراهم کرده‌است. اگرچه نوع گونه‌ای در محیط‌های کشاورزی بسیار کمتر از آکوسیستمهای بستری است، تعدادی از جمعیت‌های کنه‌های خاک‌زی، سازگاری خوبی با زمین‌های خاک‌زی‌زدی و نشده ییدا کرده‌اند. طی بک مطالعه (Acari: Prostigmata: Heterostigmatina) فونسیک‌برودی کنه‌های هترواستیگما (Acari: Heterostigmatina) در برنج خشک‌کاری 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 بندی‌بان ایران همراه با تعدادی ارتباط میژدانی جدید گزارش می‌شود. در پایان، پراکنش جهانی گونه‌های باندی و کنه‌های هترواستیگما در کنش‌های خشک‌کاری برنج در شهر گرگان ارائه شد.

واژگان کلیدی: کنه، خشک‌کاری، جنس، دانشگاه علوم کشاورزی، حیاتی‌شناسی، ایران