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# Mesostigmatic Mites Associated with Coleoptera and Biodiversity Calculation of These Mites Phoretic on Dung Beetles in Golestan Province (North of Iran)

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**Abstract:** Fauna of mesostigmatic mites associated with Coleoptera and biodiversity of these mites phoretic on dung beetles were studied in Golestan province (north of Iran). This research was carried out during 2008-2010. During this period, different beetles were collected from different parts of the province and then examined carefully. Totally 37 species of mesotigmatic mites from 21 genera, 12 families and 7 superfamilies were removed and identified from 16 different host species of Coleoptera. The mites'species were as follows: Diplogyniidae (Celaenopsoidea): *Weiseronyssus persicus* Kazemi, Klompen & Moraza, 2008; Uropodidae (Uropodoidea): *Uropoda copridis* (Oudemans, 1916); Trematuridae (Uropodoidea): *Trichouropoda elegans* (Kramer, 1882), *Nenteria stammeri* Hirschmann & Zirngiebl-Nicol, 1962; Urodinychidae (Uropodoidea): *Uroobovella fimicola* (Berlese, 1903), *Uroobovella marginata* (C.L. Koch, 1839); Eviphididae (Eviphidoidea): *Metacryptoseius persicus* Kazemi & Moraza, 2008, *Copriphis* cf. *Meyeri*, *Scarabaspis inexpectatus* (Oudemans, 1903), *Alliphis* cf. *Scarabaeorum*, *Alliphis* sp.; Macrochelidae (Eviphidoidea): *Macrocheles glaber* (J. Müller, 1860), *Macrocheles merdarius* (Berlese, 1889), *Macrocheles insignitus* Berlese, 1918, *Macrocheles robustulus* Berlese, 1904, *Macrocheles muscaedomesticae* (Scopoli, 1772), *Macrocheles scutatus* (Berlese, 1904), *Macrocheles subbadius* (Berlese, 1904), *Macrocheles* cf. *vernalis*, *Glyptholaspis americana* (Berlese, 1888), *Glyptholaspis confusa* (Foà, 1900), *Neopodocinum caputmedusae* (Berlese, 1908); Pachylaelapidae (Eviphidoidea): *Pachylaelaps pectinifer* (G. & R. Canestrini, 1881); Laelapidae (Dermanyssoidea): *Coleolaelaps costai* Joharchi & Halliday, 2011, *Gaeolaelaps nolli* Karg, 1965, *Gaeolaelaps aculeifer* (G. Canestrini, 1884), *Pneumolaelaps lubrica* Voigts & Oudemans, 1904, *Hypoaspis phyllognathi* Costa, 1971; Halolaelapidae (Rhodacaroidea): *Halolaelaps sexclavatus* (Oudemans, 1902), *Halolaelaps* sp.; Parasitidae (Parasitoidea): *Parasitus coleoptratorum* (Linnaeus, 1758), *Parasitus* cf. *kempersi*, *Parasitus fimetorum* (Berlese, 1903), *Parasitus* cf. *copridis*, *Parasitus* sp.; Ascidae (Ascoidea): *Anystipalpus livshitsi* (Eidelberg, 1989); Ameroseiidae (Ascoidea): *Ameroseius* sp. This is the first record of *Nenteria stammeri* from Iran. In the second part of the project, for biodiversity calculation of Mesostigmata phoretic on dung beetles different samplings were conducted in livestock dung (including cattle, horse and sheep dung and also poultry manure). A sample unit area of $20\times20\times10$ cm$^3$ (the length and the width were 20cm and the height was 10cm) was selected. The results were obtained by using the formula of Simpson index. Totally, the greatest number of biodiversity was obtained in cattle dung on *Euonthophagus gibbosus* (Scriba, 1790).

**Key words:** Mesostigmata · Phoretic · Coleoptera · Biodiversity · Iran

## INTRODUCTION

In comparison with the insects, mites are very smaller in size and also their sensory organs are much weaker, so they can not find suitable food resources from far distances, especially for the mites that live in temporary habitats like rotten woods, manure, carcasses or corpses. To resolve this problem many mites use other animals to arrive at suitable habitats with enough food resources that ensure high success of carried mites [1, 2]. The phenomenon in which one animal actively seeks out and clings to the body surface of another animal in a limited

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time is called phoresy. During this phenomenon, the carried animal (termed the phoretic or phoront) stops both feeding and reproduction. Phoresy results in dispersal from unsuitable habitats to the suitable ones which have better conditions for the development of the phoretic mites or their offsprings [3]. Phoresy may be facultative or obligatory. Facultative phoresy occurs in transient habitats as a result of high population or unfavorable environmental conditions. Obligatory phoresy happens in a relatively stable habitat which mites migrate in a determined seasonal cycle by the use of traditional coexisting carriers [4]. In phoretic mite species, deutonymphs or adult females are often the phoretic stages [5]. Phoretic relationships in the nature are very diverse and numerous. In some cases phoretic mites have loose liaisons with potential carriers that are available at an urgent time, but in some other cases phoretic mites have host-specificity and the host is recognized by a unique complex of physical, chemical and behavioral characters [4, 6]. In comparison with casual phoretics, those phoretic mites that have host-specificity belong to higher taxa [6]. In highly host-specific phoresy as soon as identifying the carrier, the phoretic mites could also be very easily recognized [7]. Some mite families like Macrochelidae include both genera i.e. the casual phoretics and the genera which have specific relationships with their host carriers. Also there are carriers which are the hosts for several phoretic mite species and also there are mites that can be transferred by multiple congeneric species [5]. Regarding to this point that Mesostigmata is a large and a very diverse group of mites that the majority of them are among the important beneficial predators of some agricultural pests and also by considering the importance of Coleoptera as the biggest order of insects which include about 40% of insects and also the importance of some beetles as important agricultural pests and some others as significant environmental cleaners, so this study can help us to have a better knowledge of the interaction between these mites and their beetle hosts and to find the possible effects of these mites on associated beetles. These findings can result in a better knowledge of different elements of agricultural ecosystems which can be useful in control of some pests. In this project, the biodiversity of Mesostigmata associated with dung beetles that are very important in cleaning the environment was also studied. All these data can result in better management of the environment.

## MATERIALS AND METHODS

The beetles were collected directly or using light traps during 2008-2010 in Golestan province (north of Iran). The captured beetles were placed individually in separate small boxes, killed in ethanol 75%. In laboratory they were examined carefully under stereomicroscopes. Mites were removed from beetle hosts and cleared in Nesbitt's solution and mounted on permanent slides using Hoyer's medium.

For the second part of the project, samplings were done in domestic animal manure including cattle, horse, sheep and poultry manure. Sampling was characterized by standardized observation in time and space. In this research samplings were conducted 3 times a week (Sundays, Tuesdays and Thursdays at 11 a.m.) in summer of 2010 and a sample unit area of 20×20×10 $cm^3$ (the length and the width were 20cm and the height was 10cm) was selected. For biodiversity calculation totally 36 samplings were conducted. In each sample unit the beetles were collected, placed individually and killed in ethanol 75%. All details of the samplings were recorded. Then the phoretic mites associated with the beetle hosts were removed and numbered under stereomicroscope in laboratory. For calculating the biodiversity of Mesostigmata phoretic on dung beetles the below formula of Simpson index was used:

$$1-\hat{D}=1-\sum_{i=1}^{S}\left[\frac{n_1(n_1-1)}{N(N-1)}\right]$$

$n_1$ = Number of each species in sampling
N = Total number of collected mites in sampling
S = Number of species in sampling

## RESULTS

During this study the below species were collected and identified:

**Trigynaspida**
**Celaenopsoidea**
**Diplogyniidae:** *Weiseronyssus persicus* Kazemi, Klompen & Moraza, 2008 3 females and 3 males of this species were removed from beetle hosts *Oryctes nasicornis* Linnaeus, 1758 (Dynastinae: Scarabaeidae) in Shast-kola forest in 12th of July 2009. They were found under the elytra of the hosts. The adults of this species were identified and

described for the first time taken from *O. nasicornis* in Galugah (Mazandaran province) and Shastkola region (Golestan province) in north of Iran [8].

**Monogynaspida**
**Uropodina**
**Uropodoidea**
**Uropodidae**

***Uropoda Copridis* (Oudemans, 1916):** Deutonymphs of this mite species were found in large numbers attached to the mouthparts of *Oryctes nasicornis* in Shast-kola forest in 12th of July 2009. Also deutonymphs of the species were removed from *Copris hispanus* Linnaeus, 1758 (Scarabaeidae) in Shast-kola forest in 12th of July 2009 and in Ghorogh forest in 29th of July 2009. The deutonymphs mostly were attached to the mouthparts of *C. hispanus*, but some specimens were found clinged to the legs and beneath the abdomen of the beetle hosts. *U. copridis* has worldwide distribution [9]. This mite species was found in association with *Copris lunaris* (Linnaeus, 1758) [10]. In Iran this species was removed from *C. hispanus* in Sarakhs, Razavi Khorasan province (northeast of Iran) [11].

**Trematuridae**

***Trichouropoda elegans* (Kramer, 1882):** Deutonymphs were collected in association with *Herpalus* sp. (Carabidae) and *Pentodon* sp. (Scarabaeidae) in Naharkhoran forest in 8th of June 2010. The deutonymphs were found under the elytra of the hosts. Another species of this genus, *Trichouropoda ovalis* (C. L. Koch, 1839) was reported in association with a beetle of the family Histeridae [12]. In Iran this mite has been collected from soil in Tehran region [13]. In another study deutonymphs of *Trichouropoda patavina* (G. Canestrini, 1885) were removed from *Pentodon* sp. in Torbat Heydariye (Razavi Khorasan province) and deutonymphs of *Trichouropoda* sp. were removed from *Euonthophagus* sp. (Scarabaeinae) in Galugah (Mazandaran province) [11].

***Nenteria stammeri* Hirschmann & Zirngiebl-Nicol, 1962:** Deutonymphs of this species were found on *Euonthophagus gibbosus* (Scriba, 1790) in horse dung in Zyiarat village in 4th of July 2010. This is the first record of *Nenteria stammeri* in Iran. Deutonymphs of this species has been reported from litter and soil samples in Turkey [14]. This species has also been recorded from different parts of Europe including Slovakia [15] and Finland [16].

**Urodinychidae**

***Uroobovella fimicola* (Berlese, 1903):** Deutonymphs of this species were found associated with horse dung and dung beetles *Euonthophagus gibbosus* in Toshan village, near Gorgan city in 9th of September 2010. This species has been recorded from all over Europe [17]. This mite species has been reported from Turkey [18]. *U. fimicola* was also collected from the nest of a bird species *Remiz pendulinus* (Linnaeus, 1758) in Slovakia [19]. In Iran this species has been reported from Fars, Tehran and Isfahan provinces [20]. This mite species was also removed from *Onthophagus* sp. in Bojnourd (North Khorasan province) [11].

***Uroobovella marginata* (C.L. Koch, 1839):** Deutonymphs of this species were found on *Euonthophagus gibbosus* in horse dung in Toshan village in 9th of September 2010. This species has a worldwide distribution [9] and has been reported in association with Coleoptera, Diptera, Myriapoda [21], ground skinks [22] and also the nests of different birds in Scandinavia [23]. In Iran this species has been recorded from Tehran, Isfahan [24] and Guilan [25] provinces. This species was also removed from *Euoniticellus pallens* Olivier, 1789 (Scarabaeidae) in Galugah, Mazandaran province [11].

**Gamasina**
**Eviphidoidea**
**Eviphididae**

***Metacryptoseius persicus* Kazemi & Moraza, 2008:** All stages of this mite species were collected and identified in association with three different beetle hosts. Most of the specimens were found under the elytra of *Scarabaeus transcaspicus* Stolfa, 1938 (Scarabaeidae) from Golestan forest in 5th of July 2008. But some specimens were removed from underneath the elytra of *Herpalus* sp. (Carabidae) in Naharkhoran forest in 8th of June 2010. Also they were found under the elytra of *Osphranteria coerulescens* Redtenbacher, 1850 (Cerambycidae) in Daland forest in 14th July of 2008. All stages of this species were first removed and described from the beetle host *Scarabaeus transcaspicus* from Esfarayen, North Khorasan province. Females, males and a deutonymph of this species were also found on the same host in Sarakhs, Razavi Khorasan province. Two females were also found in association with the beetle host *C. hispanus* in Sarakhs, Razavi Khorasan province [26].

***Copriphis* cf. *Meyeri*:** Females, males and deutonymphs of this species were found on *Scarabaeus transcaspicus* in Golestan forest in 5th of July 2008. They all were removed from the neck of the beetle hosts in large numbers. During the three years of sampling, this mite species has been collected only from *S. transcaspicus* and not any other species. It seems that this mite is monoxenic.

***Scarabaspis inexpectatus* (Oudemans, 1903):** Females, males and deutonymphs of this species were collected from *Euonthophagus gibbosus* and *Caccobius schreiberi* (Linnaeus, 1758) in cattle dung in Ziyarat village in 4th of July 2010 and also they were found in association with *Geotrupes* sp. in horse dung in Dangelan village (in west of Golestan province) in 13th of July 2010. During the samplings no protonymph of this species was collected but probably reproduction takes place on the host. This species has a wide distribution and has been reported from all over the Europe, the ex Soviet Union countries and Palearctic region. This mite species has been recorded phoretic on scarabaeid beetles and collected from manure [27-30]. Females and deutonymphs of this mite species were removed from the beetle hosts *Geotrupes stercorarius* (Linnaeus, 1758) and *Aphodius fossor* (Linnaeus, 1758) (Scarabaeidae) in cow dung in meadow and also their deutonymphs were found in association with *Aphodius sordidus* (Fabricus, 1775) (Scarabaeidae) in meadow, horse dung in Slovakia [12]. In Iran, females and males of this species were found on *E. gibbosus* in Esfarayen, North Khorasan province [11].

***Alliphis* cf. *Scarabaeorum*:** In this study a male of this species was found under the elytra of a male *Oryctes nasicornis* in Daland forest in 16th of June 2009.

***Alliphis* sp.:** The deutonymphs of this species were found on *Euonthophagus gibbosus* in cattle dung in Ziyarat village in 17th of August 2010.

**Macrochelidae**

***Macrocheles glaber* (J. Müller, 1860):** Females of this mite species were found on *Euonthophagus gibbosus* in cattle and sheep dung in Zyiarat village in 4th of July 2010. They were also collected in association with the same host in horse dung in Bandar Torkaman in 11th of July 2010 and in poultry manure in Galand in 10th of August 2010. In all samplings that were conducted in livestock dungs, this species was common and found in great numbers. Females of this species were also collected from underneath the elytra of *Oxythrea cinctella* (Schaum, 1841) in Roshan Abad region in 15th of June 2008. In another sampling, one female of this mite species was found beneath the elytra of a beetle host from the family Cerambycidae in Ghrogh forest in 29th of July 2009. Most of the females have fully grown eggs in their bodies. This species is cosmopolitan and it has been reported from Europe, Asia, North America and Australia. Its habitat includes decomposing organic material with enough humidity and Nitrate and specially manure [31]. This species is associated with different families of Coleoptera including Silphidae, Carabidae, Scarabaeidae, Staphylinidae, Histeridae and also different families of Diptera in animal and human decomposition [21]. This species was reported in association with 25 dung beetle species in France [32]. In Iran it has been recorded from different provinces including East Azarbayjan, West Azarbayjan, Hamadan, Kordestan, Khuzestan [20], Tehran [33] and Guilan [34]. This mite species has been collected from soils of farms and orchards, manure, mushroom, houses, honey hives [20]. This mite species was collected from two beetle hosts including *Polyphylla olivieri* Castelnau, 1840 in Bojnourd (North Khorasan province) and *Geotrupes puncticollis* Malinowski, 1811 in Shast-kola (Golestan province) [11].

***Macrocheles merdarius* (Berlese, 1889):** Females with fully grown eggs were found on dung beetle *Euonthophagus gibbosus* in cattle dung in Dangelan village in 13th of July 2010. The females were also found under the elytra of the beetle host *P. olivieri* in Alang Darre forest in 18th of June 2009. They were also removed from beneath the elytra of the beetle *Oxythyrea cinctella* in Roshan Abad in 17th of June 2010. This species has a worldwide distribution and has been reported from all continents and most regions of the world [31]. This species has been collected from dung beetles (Scarabaeidae) in Mt Merapi National Park, Jogyakarta, Indonesia [35]. *M. merdarius* was also removed from many scarabaeid beetles including *Pentodon dubius* Baillion, 1871, *Copris hispanus*, *Onthophagus binodis* Thunberg, 1818 and *Geotrupes* sp. This species was also found on hosts from the family Lucanidae, Silphidae, Trogidae and on many other dung beetles [32]. In Iran this species has been collected from different regions. This

mite was reported from button mushroom *Agaricus bisporus* (Lange) in Karaj [36]. This species was also collected from rice stores in Guilan province [25]. *M. merdarius* was reported in association with *P. olivieri* (Shast-kola, Golestan province) and *O. cinctella* (Gonabad, Razavi Khorasan province) [11].

***Macrocheles insignitus* Berlese, 1918:** Females were found on *Euonthophagus gibbosus* in cattle dung in Shast-kola region in 9th of September 2010 and two females of this mite species were found on *Onthophagus* sp. in horse dung in Zyiarat village in 24th of August 2010. This species has a wide distribution especially in Europe, but it has been reported from Siberia and China. The main habitat of this mite species is dung and especially poultry manure [31], but it has been reported in association with Coleoptera in animal and human decomposition [21] and also it has been found on bumble bees [37]. In Iran this mite has been reported from soil samples and also from manure in Tehran province [20]. It was already being found on *O. cinctella* in Mane and Samalghan region, North Khorasan province [11].

***Macrocheles robustulus* Berlese, 1904:** Females of this species were found on *Euonthophagus gibbosus* and *Geotrupes* sp. in cattle dung in Roshan Abad region in 22nd of July 2010. In another sampling that was carried out in the same region and in the same date, this mite has been removed from *Geotrupes* sp. in sheep dung. They were also found on *Herpalus* sp. (Carabidae) in Naharkhoran forest in 5th of June 2009. This species is largely widespread in the northern hemisphere, usually associated with cattle manure and dung beetles [38]. This mite is also frequently observed in greenhouse soils. *M. robustulus* can control western flower thrips significantly better (up to 70% reduction) than *Hypoaspis aculeifer* (Laelapidae) (up to 50% reduction) in a freesia greenhouse [39]. This mite was found in France mostly carried by *Onthophagus* species [32]. This phoretic mite was also found in association with another dung beetles *Aphodius tasmaniae* Hope, 1847 (Scarabaeidae) [40]. In Iran this species has been recorded from different regions [20]. *M. robustulus* was reported from Tehran [33], also from soil in Ahvaz [41] and Guilan provinces [34].

***Macrocheles muscaedomesticae* (Scopoli, 1772):** Females of this species were removed from the beetle *Pentodon* sp. from Roshan Abad in 19th of May 2009 and in another samling they were found in association with *Melolontha melolontha* Linnaeus, 1758 in Kaboud Val, Ali Abad Katoul in 7th of May 2009. This mite species was also found on *Geotrupes* sp. in sheep dung and poultry manure in Nasr Abad in 12th of September 2010. They were found under the elytra of the hosts. This species is nearly cosmopolitan and has been found in close association with the house fly, *Musca domestica* and other species of synanthropic flies and also it has been found in nests of birds, animal carrion and also in soil [38]. This mite was already removed from different Coleoptera including *Ptomaphila lacrymosa* (Schreibers, 1802) (Silphidae) [42] and from the hermit flower beetle *Osmoderma eremicola* Knock, 1801 (Scarabaeidae) [43]. *M. muscaedomesticae* was also collected in association with dung beetles (Scarabaeidae) from Mt Merapi National Park, Jogyakarta, Indonesia [35]. In Iran this species has been reported frequently [44]. This mite was collected from Tehran [33], also from soil in Ahvaz [41] and Guilan provinces [34].

***Macrocheles scutacus* (Berlese, 1904):** Two females of this species were found under the elytra of *Geotrupes* sp. in sheep dung in Gorgan in 19th of August 2010. This species has been reported from Europe, Asia, New Zealand and north of Africa and its main habitat is decomposing organic material, especially cattle and horse dung and frequently reported in association with dung beetles [31]. They were already being reported from numerous scarabaeid beetles including *Geotrupes spiniger* Marsham, 1802, *G. stercorarius* (Linnaeus, 1758), *Copris lunaris*, *Copris umbilicatus* Abeille de Perrin, 1901 and *Aphodius scrutator* (Herbst, 1789) [45].

In another survey, this species was found in association with four other scarabaeid beetles i.e. *Aphodius suarius* Faldermann, 1836, *Bubas bubalus* (Olivier, 1811), *Euoniticellus fulvus* (Goeze, 1777) and *Onthophagus vacca* (Linnaeus, 1767) in France [32]. In Iran, during 1997-1998 and in a faunastic survey on mites associated with grapevine in Khuzestan, south western province of Iran, *M. scutacus* was collected and identified for the first time in the country [46]. *M. scutacus* was also collected from Tehran [33]. There are reports that this species was found in association with the two different beetle hosts from the family Scarabaeidae including *O. cinctella* from Mane and Samalghan, North Khorasan province and also from *Onthophagus* sp. in manure from Esfidan, Bojnourd, North Khorasan province [11].

***Macrocheles subbadius* (Berlese, 1904):** Two females of this mite species were collected and identified in association with *Geotrupes* sp. in poultry manure in Roshan Abad in 26th of August 2010. *M. subbadius* has been mostly recorded in the world in association with Diptera [32, 47, 48, 49, 50, 51]. Sometimes they have phoretic associations with mammals [37, 40, 50, 52, 53]. This species has already been recorded from Iran [20, 44]. *M. subbadius* was collected in association with button mushroom [36].

***Macrocheles* cf. *Vernalis*:** Females of this species were removed from different hosts including beneath the elytra of *Scarabaeus transcaspicus* (Scarabaeidae) from national park of Golestan in 5th of July 2008, between pronotum and mesonotum of *Capnodis tenebrionis* (Linnaeus, 1767) (Buprestidae) from Ghorogh in 29th of July 2009 and under the elytra of *Herpalus* sp. (Carabidae) from Naharkhoran in 8th of June 2010.

***Glyptholaspis Americana* Berlese, 1888:** Females of *G. americana* were found on *Euonthophagus gibbosus* in cattle dung and horse dung in Ziyarat village in 17th of August 2010. Most of the females have fully grown eggs in their body. *G. americana* is cosmopolitan and it is mostly found in dung and leaf litter [54, 55, 56]. This mite is widely known to be transported by dung beetles, however, it was also found on corpses [57, 58]. There are reports that this species has been found in association with beetles from the family Scarabaeidae including *Bubas bison* (Linnaeus, 1767) [59], *Copris hispanus*, *Onitis aygulus* (Fabricus, 1781), *Onthophagus granulatus* Boheman, 1858, *O. australis* Guerin, 1830 [60] and also on *Geotrupes spiniger* Marsham [37]. This species has already been reported from different regions of Iran including Tehran [33, 61].

***Glyptholaspis confusa* (Foà, 1900):** Females of *G. confusa* were collected from *Euonthophagus gibbosus* in cattle dung in Zyiarat village in 17th of August 2010. The majority of the females have fully grown eggs in their bodies. This species is cosmopolitan in dung and compost [54, 55, 56] and is reported from Europe, Turkmenistan, Uzbekistan, Argentina, Australia and New Zealand [31]. This mite is frequently found on Musicidae in decomposing animal and human corpses [21]. During a survey that was conducted on phoretic Macrochelidae in Morocco, this mite species was removed from several dung beetles from the family Scarabaeidae including *Typhoeus typhoeus* (Linnaeus, 1758), *Bubas bison*, *Euoniticellus fulvus* (Goeze 1777) and *Euonthophagus crocatus* Mulsant, 1873 [59]. *G. confusa* was also recorded in association with scarabaeid beetles *Onthophagus gazella* (Fabricus, 1787), *O. australis* Guerin, 1830, *Euoniticellus intermedius* (Reiche, 1849) and *Liatongus militaris* (Castelnau, 1840) [60]. This mite has been collected directly from bovine dung pats [62]. In Iran this mite species has been reported from different regions [20, 44] including from manure in Tehran [33] and it was also removed from *P. olivieri* in Shast-kola region in Golestan province [11].

***Neopodocinum caputmedusae* (Berlese, 1908):** Two females of this species were found attached to the mouthparts of the host beetle *Copris hispanus* in Shast-kola forest in 22nd of June 2008. This species has been reported in association with *C. hispanus* in Crimea, Central Asia, south part of Bulgaria, Italy, Israel and Algeria; with *Homalocopris tmolus* Fischer von Waldheim, 1821 (Scarabaeidae) in Turkestan and with *Scarabaeus sacer* Linnaeus, 1758 (Scarabaeidae) in Turkey [63]. In earlier studies that were carried out in Iran, all stages of this mite were recorded on *C. hispanus* around Lake Bezangan, Sarakhs, Razavi Khorasan province (11). It seems that this species can copulate and reproduce on host *C. hispanus*.

**Pachylaelapidae**

***Pachylaelaps pectinifer* (G. & R. Canestrini, 1881):** Females and males of this species were found in ethanol containing of the box used for keeping the beetle host *C. hispanus* collected from an orchard in Marzankalateh in 25th of June 2009. This species has a wide distribution especially in Europe and is hygrophilous [64]. *P. pectinifer* was also collected in association with *Copris lunaris* in France [65]. In earlier studies carried out in Iran, females and males of the species have been recorded from the host *Scarabaeus transcaspicus* in Galugah, Mazandaran province [11]. This mite was also collected from soil in Nowshahr, Mazandaran province [66].

**Dermanyssoidea**

**Laelapidae**

***Coleolaelaps costai* Joharchi & Halliday, 2011:** Females of this mite species were removed from underneath the

elytra of the beetle hosts *Melolontha melolontha* from Kordkooy forest in 7th of July 2009. Females of this species were first collected and described taken from *Polyphylla olivieri* in Tehran [67] and this is the second report of *C. costai* from Iran.

***Gaeolaelaps nolli* Karg, 1962:** Two females of this species were collected from underneath the elytra of *Pentodon* sp. in Naharkhoran forest in 26th of August 2008. This mite has been reported from Asia and Europe [68, 69]. In Iran this species has been reported from soil in Khuzestan, East Azarbaijan [20] and Guilan provinces [70]. In another study, one female of this species was collected in association with an unknown species of *Pentodon* in Torbat Heydariyeh, Razavi Khorasan province in Northeast of Iran [11]. This species was also collected during a study on mites associated with insects in Chaharmahal-Bakhtiari, Khuzestan and Bushehr provinces [71].

***Gaeolaelaps aculeifer* (G. Canestrini, 1884):** One female of this species was removed from underneath the elytra of *Pentodon* sp. in Golestan forest in 18th of August 2009. This species has a worldwide distribution and has been reported from Europe, Asia, America, Canada and Russia. This mite feeds on storage mites, Collembola, thrips and nematodes and in the whole this mite is an edaphic polyphagous predator that feeds on various food resources [72]. In Iran this mite species has been frequently reported from different regions including Shahrekord [73], East Azabaijan, West Azarbaijan, Fars, Sistan and Balouchestan [74], Isfahan, Guilan, Hamadan and Khuzestan from stores, alfalfa, clover, sugerbeet, potato farms and also from soil and the nest of small mammals [70].

***Pneumolaelaps lubrica* Voigts & Oudemans, 1904:** The females of this species were collected in association with *Geotrupes* sp. in horse dung in Toshan village in 9th of September 2010. This species has been reported from Asia and Europe [75]. In Iran, *P. lubrica* was collected from rice stores in Guilan province [25]. The females of this species were also removed from beneath the elytra of *O. cinctella* from Bojnourd, North Khorasan province [11].

***Hypoaspis phyllognathi* Costa, 1971:** The females of this mite species were found abundantly associated with *Oryctes nasicornis* and *Polyphylla olivieri* in Shast-kola forest in 22nd of June 2008. Necessary to say only one male of the species was also collected from *P. olivieri*. In another sampling females of this mite were removed from *Phyllognathus silenus* Fabricius, 1775 (Scarabaeidae) in Ghorogh forest in 28th of June 2008. They have been found under the elytra of these three beetle hosts. *H. phyllognathi* was first collected and described taken from beetles of the genus *Phyllognathus* in Egypt and Israel [76]. In Iran this species was collected from *P. olivieri* from Shast-kola region [11]. The females of this species were also removed from *Phyllognathus* sp. in Khaf, Shiraz, Fars province [67].

**Rhodacaroidea**

**Halolaelapidae**

***Halolaelaps sexclavatus* (Oudemans, 1902):** Deutonymphs of this species were removed from *Herpalus* sp. (Carabidae) in Kordkooy forest in 7th of July 2009. The deutonymphs were found under the elytra of the hosts. This mite has been reported from different European countries [77]. Compost and dung are the main habitats of this species [78]. In Iran deutonymphs of this mite have been removed from underneath the elytra of the two different beetle hosts including *O. cinctella* in Gonabad, Razavi Khorasan province and *Onthophagus* sp. in Bojnourd, North Khorasan province [11].

***Halolaelaps* sp.:** Two deutonymphs of this species were removed from beetle dung *Euonthophagus gibbosus* in cattle dung in Zyiarat village in 17th of August 2010.

**Parasitoidea**

**Parasitidae**

***Parasitus coleoptratorum* (Linnaeus, 1758):** Deutonymphs of this species were found abundantly on *Euonthophagus gibbosus* and *Caccobius schreiberi* in cattle and horse dung in Zyiarat village in 17th of August 2010. In another sampling that was carried out in Roshan Abad region in 22nd of July 2010, the deutonymphs of the species were removed from *Geotrupes* sp. and *E. gibbosus* in sheep dung and also from *E. gibbosus* in poultry manure. This species has a worldwide distribution and has been reported as phoretic deutonymphs on different hosts including scarabaeid beetles [28]. This species was removed from *Copris hispanus* (L.) [79]. *Parasitus coleoptratorum* was also recorded from button

mushroom (*Agaricus bisporus*) in Karaj region [36]. The deutonymphs of this mite species were removed from different scarabaeid beetles including *Polyphylla olivieri*, *Geotrups puncticollis* and *O. cinctella* in Shast-kola region and also from *Euoniticellus pallens* in Galugah, Mazandaran province and from *Onthophagus* sp. in Bojnourd, North Khorasan province [11].

***Parasitus* cf. *Kempersi*:** Deutonymphs of this species were collected from *Euonthophagus gibbosus* in cattle dung in Nasr Abad village in 25th of July 2010. The morphological characteristics of this species are very similar to *P. kempersi*. The main habitat of *P. kempersi* is seashore soils [80, 81] but it has also been reported from meadows [82].

***Parasitus fimetorum* Berlese, 1903:** Deutonymphs of the species were found in cattle dung in association with *Euonthophagus gibbosus* in Zyiarat village in 4th of July 2010 and in Nasr Abad village in 25th of July 2010. This species has been recorded from all over European countries [83, 84]. It has also been reported from Australia [85]. This mite is found in forest, compost and decaying organic substrates. It prefers humid areas [83, 84]. This mite species was collected in dung independently and also in association with *Onthophagus granulutus* and *O. australis* in south eastern Australia [85]. *Parasitus fimetorum* was recorded from gladiolus in Turkey [86]. This mite has also been found in association with beetles of the family Silphidae and Scarabaeidae on animal and human decomposition [21]. This species was removed from *Pterostichus nigrita nigrita* (Paykull, 1790) (Carabidae); *Hister bissexstriatus* Fabricus, 1801 (Histeridae) and *Platycerus caraboides caraboides* (Linnaeus, 1758) (Lucanidae) [12]. In Iran *P. fimetorum* was recorded from the soil in Ahvaz region [41]. This mite species was also collected during a study on mites fauna associated with button mushroom in Karaj region [36]. This species has also been found in association with several beetle hosts including *Euonthophagus amyntas* (Olivier, 1789) in Bojnourd, North Khorasan province, from *P. olivieri* in Shast-kola region, Golestan province and also from *Euoniticellus pallens* in Galugah, Mazandaran province [11].

***Parasitus* cf. *Copridis*:** Deutonymphs of this species were collected from *Euonthophagus gibbosus* in cattle dung in Zyiarat village in 17th of August 2010 and a deutonymph of the species was also found on the same host in horse dung in Nasr Abad village in 25th of July 2010. The morphological characteristics of this species are very similar to *P. copridis*. This species is associated with scarabaeid and carabid beetles [80]. *P. copridis* was removed from *Copris hispanus* (L.) in Israel [87] and it was also found in nests of the dung beetle *Copris lunaris* (Linnaeus, 1758) (Scarabaeidae) in Slovakia [10]. This species has also been reported in association with *Geotrupes stercorarius* (Linnaeus, 1758) and *Aphodius sordidus* (Fabricius, 1775) (Scarabaeidae) in horse dung [12].

***Parasitus* sp.:** Deutonymphs of this species were found on *E. gibbosus* and *Caccobius schreiberi* in cattle dung in Zyiarat village in 17th of August 2010. Some specimens were also collected in association with *E. gibbosus* in sheep dung in Roshan Abad region in 22nd of July 2010. They were very abundant on the hosts.

**Ascoidea**

**Ascidae**

***Anystipalpus livshitsi* (Eidelberg, 1989):** Females of this mite were removed from underneath the elytra of *Herpalus* sp. (Carabidae) in Daland forest in 16th of June 2009. It seems that this mite species is widely distributed across east central Europe and west central Asia in association with numerous carabid beetles [88]. Adult females of this species were first removed from underneath the elytra and above the folded wings of different carabid beetles from Moldavia, Crimea and Kazakhstan [89]. The females of this species were also collected from beneath the elytra of some carabids from Crimea and Ukrain [90]. The female of *Anystipalpus livshitsi* was redescribed taken from beneath the elytra of a carabid beetle *Ophonus* (*Metophonus*) *rufibarbis* (Fabricius) collected from Iran, Esfarayen, North Khorasan province [88].

**Ameroseiidae**

***Ameroseius* sp.:** Females of this species were found in horse dung, cattle dung and sheep dung associated with *E. gibbosus* in Dangelan village in 2nd of September 2010. Another species of this mite genus was recorded in association with *Hylurgops palliatus* (Gyllenhal, 1813) (Scolytidae) [12].

**Key to the Identified Species**

1- females with 3 epigynal shields (2 latigynal and 1 mesogynal); latigynal shields well developed, each with 2 setae, mesogynal shield nude, small, triangular, overlapped marginally by latigynals and free from ventrianal plate; in males sternal setae *st1* much longer than *st2* and *st3*; movable digit with brushy excrescence; males and females with denticulate sucapitular setae .....
.....*Weiseronyssus persicus* Kazemi, Klompen & Moraza, 2008 (Diplogyniidae)
- Females with one epigynal shield; chelicerae without such excrescence.....2
2- Dorsal shield without marginal shields or platelets, peritreme often linear, hypostomatic setae h2 are not longitudinally aligned with h1 and h3, different stages associated with the beetle hosts.....cohort Gamasina-7
- Dorsal shield with marginal shields or platelets, peritreme often sinuous, hypostomatic setae h2 and h3 longitudinally aligned, only deutonymphs associated with beetle hosts .....
cohort Uropodina-3
3- Chelicerae with nodus.....4
-Chelicerae without nodus, h1 long and setiform, sternal shield is free from endopodal plates, seta *al-1* of pedipalpus' trochanter with one small basal denticle, pritreme is sinuous in middle and in the anterior part, pedofossae well developed
.....*Uropoda copridis* (Oudemans, 1916) (Uropodidae)
4- Internal malae of hypostome simple, without marginal fimbriation or distal moustachelike excrescences, fixed digit of chelicerae without apical finger.....Trematuridae.....5
- Internal malae with short marginal fimbriation and/or with distinctive distal moustachelike excrescences, fixed cheliceral digit with an apical "finger" that extends well beyond the movable digit. Peritremes well developed and often form distinctive spiral patterns.....Urodinychidae....6
5- Tectum dentate, its anterior projection is lancet-like, each chelicera with a dorsal seta, corniculi denticulate, laciniae of hypostomes without paralaciniae, dorsal shield with polygonal reticulation; dorsal setae long, plumose and nearly stout
.....*Trichouropoda elegans* (Kramer, 1882)
- Tectum edentate, its projection fusiform, chelicerae without dorsal setae, corniculi conical and without denticles, prolongation of tritosternum with long middle branch, laciniae of hypostome with paralaciniae, dorsal setae short; sternal shield, with distinctly semicircle patterns, has fused to endopodal elements .....
..... *Nenteria stammeri* Hirschmann & Zirngiebl-Nicol, 1962
6- Sternal shield narrow; pedofossae absent.....*Uroobovella fimicola* (Berlese, 1903)
- Sternal shield broad; pedofossae present.....*Uroobovella marginata* (C. L. Koch, 1839)
7- Palptarsal apotele always 3-tined; genu III with a posteroventral seta (pv) and two posterolateral setae (pl), genu IV with a posteroventral seta (pv).....Parasitidae...8
- Palptarsal apotele 2- or 3-tined; other characteristics not as above.....12
8- Dorsal shield without setae much longer or stouter than other setae although j1, z5 and r3 are generally the longest; tectum trispinate with lateral prongs acuminate and the median prong broad and dentate distally; presternal shields small and sternal setae st1 on an entire sternal shield; setae s5 much finer than z5; opisthonotal shield bearing 15 pairs of setae.....*Parasitus fimetorum* (Berlese, 1903)
- Some dorsal setae in addition to j1, z5 and r3 conspicuously stouter and longer than the other setae .....9
9- Opisthonotal shield bearing 14 pairs of setae; setae Z3 very long and pilose distally.....10
- s6 short; opisthonotal shield bearing more than 14 pairs of setae, Z3 not very long.....11
10- s6 unusually long.....*Parasitus* cf. *copridis*
- s6 not so long .....*Parasitus* sp.
11- Tectum quinque-spinate; seta j4 long and pilose distally; opisthonotal shield bearing 16 pairs of setae; sternal shield blunt posteriorly and setae st4 situated near the posterior margin of the shield.....*Parasitus coleoptratorum* (Linnaeus, 1758)
- Tectum trispinate with median projection less than twice as long as laterals; seta j4 not conspicuously long;

opisthonotal shield with 15 pairs of setae of which Z3 are long and stout and J5 are thornlike; sternal shield tapered abruptly behind st4 .....*Parasitus* cf. *kempersi*

12- Tibia and genu I each with 1 anterolateral seta (al); tectum usually grow into an elongated, lancelike process, rarely multidenticulate, dorsal shield entire; female and male with anal shield.....Eviphididae....13

-Tibia and genu I each with 2 anterolateral seta (al).....17

13- Peritremes wide and short, never reaching beyond anterior margin of coxae II; peritrematal shields reduced, without post-stigmatic extensions; dorsal shield hypotrichous, with 26 pairs of setae and not covering the whole dorsum; Metasternal seta st4 and associated pore placed on small metasternal platelets; sternal shield with two pairs of pores; dorsocentral setae subequal in length; setae JV5 about five times longer than J5; setae z2 almost equal in length to s2; dorsal setae on shield without extreme differences in length; setae J5 and Z5 subequal; males with setae z2 and s2 subequal and s2 as long as r3.....*Metacryptoseius persicus* Kazemi & Moraza, 2008

- Peritremes narrow, long enough to extend anteriorly beyond coxae I; peritrematal shield well developed, with post-stigmatic extensions; dorsal shield with full set of 30 pairs of setae, covering the whole dorsum ..... 14

14- Post-stigmatic section of peritrematal shields well extended, with tip reaching beyond level of posterior margin of genital shield; idiosoma dorso-ventrally flattened; vertical setae j1 stout and lance-like; metapodal plates widely separated from peritrematal shields by a strip of soft cuticle; hypertrophied post-stigmatic pores inserted close to posterior end of peritrematal shields; setae st3-st5 in females and males and setae st2-st5 in deutonymphs flattened, lanceolate and spur-like; trochanter I bearing six setae, genu III bearing eight setae; marginal setae long, reaching well beyond the insertion of the following setae ..... *Copriphis* cf. *Meyeri*

- Post-stigmatic section of peritrematal shields short, not exceeding the posterior margin of coxae IV .....15

15- Coxae I and II totally with 6 modified button-like ventral setae; genital setae situated outside genital shield; length and width of chelicerae normal; ventral setae fine and setiform.....*Scarabaspis inexpectatus* (Oudemans, 1903)

- Coxae I and II with normal needle-like setae; genital setae situated on genital shield; peritrematal shield developed along whole length of peritreme; anterior section of peritrematal shield completely fused to dorsal shield; dorsal shield smooth or finely reticulated and the posterior setae of the shield subequal or only moderately varying in length; exopodal platelets I-II present.....*Alliphis* Halbert, 1923...16

16- Dorsal setae homogenous.....*Alliphis* sp.

- Dorsal setae not homogenous; setae on the postero-lateral margins of the dorsal shield longer than the other setae; in male antero-lateral and postero-lateral corners of the sternigenital shield bluntly pointed ..... *Alliphis* cf. *Scarabaeorum*

17- Stenal shield with 4 pairs of setae; in female genital shield is fused with ventral shield; peritermatal shield expanded and fused with exopodal shield; setae J5 very short; tarsus II in female and male with 2 pre-apical thick spines; big glands of the lateral parts of opisthonotal region (gdZ1, gdS4) close together; cornicles long and slender; females' sperm access system is related to coxae IV .....

.....*Pachylaelaps pectinifer* (G. & R. Canestrini, 1881) (Pachylaelapidae)

- Stenal shield with 2-3 pairs of setae; in female genital shield is separated from a ventrianal or anal shield or, with a genitiventral shield; peritermatal shield not expanded and free from exopodal shield; tarsus II usually without pre-apical thick spines in female but sometimes with such attributes dimorphically in male.....18

18- Female sternal shield with 2 pairs of setae; sternal setae st3 on soft cuticle, setae J5 and marginal R setae absent; corniculi dentate distally; posterior row of deutosternal denticles extending laterally beyond insertions of capitular setae; femur II bearing 10 setae, including 4 dorsals; the upper side of female genital shield is composed of two crescent parts.....*Ameroseius* sp. (Ameroseiidae)

- Female sternal shield with 3 pairs of setae; setae J5 and usually one or more marginal R setae present; corniculi entire.....19

19- Peritremes bend proximally, joining the stigmata posteriorly (except genus *Neopodocinum*); tarsus I without claws

(except genus *Neopodocinum*); females with a pair of well developed accessory sclerites underneath the lateral margins of genital shields; apotele always 3-tined; only females associated with hosts .....Macrochelidae...20

-Peritremes normal, joining the stigmata anteriorly; tarsus I with claws; females with accessory sclerites faint or absent underneath the lateral margins of genital shields; apotele 2- or 3-tined; females or deutonymphs associated with hosts.....30

20- Peritremes join the stigmata anteriorly or laterally; tarsus I with claws; anal shield small, oval, bearing 3 circumanal setae; dorsal setae conspicuously heterogenous with short, thin median setae and long marginal setae; dorsal shield narrowed towards the posterior end.....*Neopodocinum caputmedusae* (Berlese, 1908)

- Peritremes join the stigmata posteriorly; tarsus I without claws; with 3 pairs of preanal setae; marginal setae of the dorsal shield are not much longer than the other dorsal setae ……..……..... .....21

21- Sternal shield with posterior margin deeply curved, extending to level of posterior margins of coxae III; ventrianal shield is wider than long; shields conspicuously sculptured.....……..……..…...*Glyptholaspis* Filipponi and Pegazzano...22

- Sternal shield with straight (or slightly curved) posterior margin, not extending beyond middle of coxae III; sternal shield variously sculptured, but without conspicuous reticulate ornamentation..……..…*Macrocheles* Latreille, 1829…23

22- Dorsal setae j5, j6, J1, z4 long; fine, smooth or slightly pilose; seta j5 as long as distance between j5 and j6; suplementary seta(e) Jx absent .....*Glyptholaspis americana* (Berlese, 1888)

- Dorsal setae j5, j6, J1, z4 short, thick, strongly pilose; seta j5 about half of distance between j5 and j6; suplementary seta(e) Jx usually present.....*Glyptholaspis confusa* (Foà, 1900)

23- Seta j1 simple and smooth……..……..…24

- Seta j1 not smooth…….……..26

24- Genua IV with 7 setae……..*Macrocheles subbadius* (Berlese, 1904)

- Genua IV with 6 setae…….25

25- Sternal shield finely sculptured, sculptural lines with micropunctations, seta J2 less than one-thirds of distance between J2 and Z4, seta Z4 about one-thirds of distance between Z4 and Z5…….....*Macrocheles merdarius* (Berlese, 1889)

- Sternal shield strongly sculptured, sculptural lines with large punctures, seta J2 about half of distance between J2 and Z4, seta Z4 more than half of distance between Z4 and Z5……...…*Macrocheles insignitus* Berlese, 1918

26- All lateral and marginal setae plumose, pilose or serrate; minority of dorsal setae including j5 simple, smooth and acicular.....*Macrocheles muscaedomesticae* (Scopoli, 1772)

- All or most lateral and marginal setae simple and smooth; most dorsal setae simple, smooth and acicular……...……..……..……27

27- Ventral shields weakly sculptured and ornamented with lines; sternal shield with conspicuous linea arcuata..……..……...*Macrocheles* cf. *vernalis*

- Ventral shields strongly sculptured and ornamented with punctures and lines……...28

28- Sternal shield irregularly and finely sculptured with punctures of different size; ventianal shield slim and elongated…….....…*Macrocheles robustulus* Berlese, 1904

- Sternal shield sculptured with a distinct pattern of lines and small puncture areas; ventrianal shield broader and pentagonal…….....…..……..29

29- Linea arcuata short, straight or slightly concave, with ends directed laterally or posteriorly; all lines of sternal shield conspicuous and connected to eachother by small pits…….....…….*Macrocheles glaber* (J. Müller, 1860)

- Linea arcuata longer, strongly concave, with ends directed anteriorly; some sternal lines not distinc and connected to eachother by large pits .....*Macrocheles scutacus* (Berlese, 1904)

30- Sternal shield without lyrifissure; podonotal shield bearing eight pairs of strongly stout, smooth, thorn-like setae; stout dorsal setae shorter (half as long) than other setae of podonotal shield and with rounded, blunt tips; genital shield

drop-shaped with lateral margins widened posteriorly; setae pd on trochanter I, pd2 on femur I and pd-1-pd3 on genu I, short, thick, bluntly spike-like ..... .....*Anystipalpus livshitsi* Lindquist & Moraza, 2009 (Ascidae)
- Sternal lyrifissures with lyriffisures.....……..……31
31- Dorsal shield entire, mostly females are associated with hosts…….Laelapidae…32
-Dorsal shield divided into podonotal and opisthonotal shields; only deutonymphs are associated with hosts……..…Halolaelapidae….36
32- Dorsal shield with 28 pairs of setae; podonotal section of the dorsal shield is much wider than the opisthonotal section which separated from eachother by lateral incisions at a level between j6 and J1; S5 very long and wavy inserted on dorsal shield, other S series setae outside the shield; z1 short, all other setae long; st1 is off sternal shield ..... *Coleolaelaps costai* Joharchi & Halliday, 2011
- Dorsal shield with more than 30 pairs of setae and without the above characteristics...33
33- Stigmata and pritreme almost broad; opisthogaster with 15 pairs of setae; seta j5 is half of distance between j5 and j6.....*Pneumolaelaps lubrica* Voigts & Oudemans, 1904
- Stigmata and pritreme normal; opisthogaster with less than 11 pairs of setae……..…..34
34- Legs bearing some elongated setae; dorsal shield with one or more than one setae much more longer than the others; sternal shield is wider than long at the level of st2; j6 is longer than the distance between j6 and J1...……...*Hypoaspis phyllognathi* Costa, 1971
- Legs without very long setae.....*Gaeolaelaps* Evans and Till, 1966…35
35- Peritreme short and reaches only at the anterior margin of coxae II
.....*Gaeolaelaps nolli* Karg, 1965
- Peritreme reaches at the at the anterior margin of coxae I
.....*Gaeolaelaps aculeifer* (G. Canestrini, 1884)
36- setae pv-1 of coxae II and III and capitular setae modified into oval and flat protuberance.....*Halolaelaps sexclavatus* (Oudemans, 1902)
- setae pv-1 of Coxae I, II, III and capitular setae with modified setae…...*Halolaelaps* sp.

**Biodiversity of Mesostigmatic Species Phoretic on Dung Beetles**

**Biodiversity Estimation of the Species Collected in Cattle Dung:** Totally 15 mesostigmatic mite species from 5 different families were collected from three dung beetles including *Euonthophagus gibbosus*, *Caccobius schreiberi* and *Geotrupes* sp. in cattle dung which were as follows (names of the beetle host(s) has been written in crochets):

Eviphididae
*Scarabaspis inexpectatus* [*Euonthophagus gibbosus*, *Caccobius schreiberi*]
*Alliphis* sp. [*Euonthophagus gibbosus*]

Macrochelidae
*Macrocheles glaber* [*Euonthophagus gibbosus*]
*Macrocheles merdarius* [*Euonthophagus gibbosus*]
*Macrocheles insignitus* [*Euonthophagus gibbosus*]
*Macrocheles robustulus* [*Euonthophagus gibbosus*, *Geotrupes* sp.]
*Glyptholaspis americana* [*Euonthophagus gibbosus*]
*Glyptholaspis confusa* [*Euonthophagus gibbosus*]

Halolaelapidae
*Halolaelaps* sp. [*Euonthophagus gibbosus*]

Parasitidae
*Parasitus coleoptratorum* [*Euonthophagus gibbosus*, *Caccobius schreiberi*]
*Parasitus cf. kempersi* [*Euonthophagus gibbosus*]

*Parasitus fimetorum* [*Euonthophagus gibbosus*]
*Parasitus cf. copridis* [*Euonthophagus gibbosus*]
*Parasitus* sp. [*Euonthophagus gibbosus*, *Caccobius schreiberi*]

Ameroseiidae
*Ameroseius* sp. [*Euonthophagus gibbosus*]

Biodiversity estimation on *E. gibbosus*:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{32(32-1)}{523(523-1)}+\frac{4(4-1)}{523(523-1)}+\frac{83(83-1)}{523(523-1)}+\frac{3(3-1)}{523(523-1)}+\frac{3(3-1)}{523(523-1)}+\frac{22(22-1)}{523(523-1)}+\frac{2(2-1)}{523(523-1)}+\frac{5(5-1)}{523(523-1)}+\frac{2(2-1)}{523(523-1)}+\frac{162(162-1)}{523(523-1)}+\frac{36(36-1)}{523(523-1)}+\frac{9(9-1)}{523(523-1)}+\frac{3(3-1)}{523(523-1)}+\frac{152(152-1)}{523(523-1)}+\frac{5(5-1)}{523(523-1)}\right)=0.78$$

Species 1= *Scarabaspis inexpectatus*; $n_1$=32 (20DN, 8♀, 4♀)
Species 2= *Alliphis* sp.; $n_2$=4(DN)
Species 3= *Macrocheles glaber*; $n_3$=83(♀)
Species 4= *Macrocheles merdarius*; $n_4$=3(♀)
Species 5= *Macrocheles insignitus*; $n_5$=3(♀)
Species 6= *Macrocheles robustulus*; $n_6$=22(♀)
Species 7= *Glyptholaspis americana*; $n_7$=2(♀)
Species 8= *Glyptholaspis confusa*; $n_8$=5(♀)
Species 9= *Halolaelaps* sp.; $n_9$=2(DN)
Species 10= *Parasitus coleoptratorum*; $n_{10}$=162(DN)
Species 11= *Parasitus* cf. *kempersi*; $n_{11}$=36(DN)
Species 12= *Parasitus fimetorum*; $n_{12}$=9(DN)
Species 13= *Parasitus* cf. *copridis*; $n_{13}$=3(DN)
Species 14= *Parasitus* sp.; $n_{14}$=152(DN)
Species 15= *Ameroseius* sp.; $n_{15}$=5(♀)

Biodiversity estimation on *C. shreiberi*:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{9(9\text{-}1)}{73(73\text{-}1)}+\frac{48(48\text{-}1)}{73(73\text{-}1)}+\frac{16(16\text{-}1)}{73(73\text{-}1)}\right)=0.51$$

Species 1= *Scarabaspis inexpectatus*; $n_1$=9 (6DN, 3♀)
Species 2= *Parasitus coleoptratorum*; $n_2$=48(DN)
Species 3= *Parasitus* sp.; $n_3$=16(DN)

Biodiversity estimation on *Geotrupes* sp.:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{2(2-1)}{2(2-1)}\right)=0$$

Species= *Macrocheles robustulus*; n=2(♀)

**Biodiversity Estimation of the Species Collected in Horse Dung:** In horse dung 11 mite species from 7 families were found in association with the four different dung beetles including *E. gibbosus*, *Onthophagus* sp., *C. shreiberi* and *Geotrupes* sp. The list of these species was as below (names of the beetle host(s) has been written in crochets):

Trematuridae
*Nenteria stammeri* [*E. gibbosus*]

Urodinychidae
*Uroobovella fimicola* [*E. gibbosus*]
*Uroobovella marginata* [*E. gibbosus*]

Eviphididae
*Scarabaspis inexpectatus* [*Geotrupes* sp.]

Macrochelidae
*Macrocheles glaber* [*E. gibbosus*]
*Macrocheles insignitus* [*Onthophagus* sp.]
*Glyptholaspis americana* [*E. gibbosus*]

Laelapidae
*Pneumolaelaps lubrica* [*Geotrupes* sp.]

Parasitidae
*Parasitus coleoptratorum* [*E. gibbosus*, *C. schreiberi*]
*Parasitus* cf. *copridis* [*E. gibbosus*]

Ameroseiidae
*Ameroseius* sp. [*E. gibbosus*]

Biodiversity estimation on *E. gibbosus*:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{7(7-1)}{108(108-1)}+\frac{5(5-1)}{108(108-1)}+\frac{2(2-1)}{108(108-1)}+\frac{48(48-1)}{108(108-1)}+\frac{1(1-1)}{108(108-1)}+\frac{32(32-1)}{108(108-1)}+\frac{1(1-1)}{108(108-1)}+\frac{12(12-1)}{108(108-1)}\right)=0.7$$

Species 1= *Nenteria stammeri*; $n_1$=7(DN)
Species 2= *Uroobovella fimicola*; $n_2$=5(DN)
Species 3= *Uroobovella marginata*; $n_3$=2(DN)
Species 4= *Macrocheles glaber*; $n_4$=48(♀)
Species 5= *Glyptholaspis americana*; $n_5$=1(♀)
Species 6= *Parasitus coleoptratorum*; $n_6$=32(DN)
Species 7= *Parasitus* cf. *copridis*; $n_7$=1(DN)
Species 8= *Ameroseius* sp.; $n_8$=12(♀)

Biodiversity estimation on *C. shreiberi*:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{8(8-1)}{8(8-1)}\right)=0$$

Species= *Parasitus coleoptratorum*; n=8(DN)

Biodiversity estimation on *Geotrupes* sp.:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{12(12-1)}{14(14-1)}+\frac{2(2-1)}{14(14-1)}\right)=0.264$$

Species 1= *Scarabaspis inexpectatus*; $n_1$=12 (9DN, 3♀)
Species 2= *Pneumolaelaps lubrica*; $n_2$=2(♀)

Biodiversity estimation on *Onthophagus* sp.:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{2(2-1)}{2(2-1)}\right)=0$$

Species= *Macrocheles insignitus*; n=2(♀)

**Biodiversity Estimation of the Species Collected in Sheep Dung:** In the samplings that were conducted to estimate the mesostigmatic mites' biodiversity in sheep dung, 7 mite species from 3 different families of Mesostigmata were collected. The beetle hosts included *E. gibbosus* and *Geotrupes* sp. The lists of the collected mite species are as follows (names of the beetle host(s) has been written in crochets):

Macrochelidae
*Macrocheles glaber* [*E. gibbosus*]
*Macrocheles robustulus* [*Geotrupes* sp.]
*Macrocheles muscaedomesticae* [*Geotrupes* sp.]
*Macrocheles scutacus* [*Geotrupes* sp.]

Parasitidae
*Parasitus coleoptratorum* [*E. gibbosus*, *Geotrupes* sp.]
*Parasitus* sp. [*E. gibbosus*]

Ameroseiidae
*Ameroseius* sp. [*E. gibbosus*]

Biodiversity estimation on *E. gibbosus*:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{15(15-1)}{58(58-1)}+\frac{18(18-1)}{58(58-1)}+\frac{22(22-1)}{58(58-1)}+\frac{3(3-1)}{58(58-1)}\right)=0.7$$

Species 1= *Macrocheles glaber*; $n_1$=15
Species 2= *Parasitus coleoptratorum*; $n_2$=18
Species 3= *Parasitus sp.*; $n_3$=22
Species 4= *Ameroseius* sp.; $n_4$=3

Biodiversity estimation on *Geotrupes* sp.:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{8(8-1)}{14(14-1)}+\frac{2(2-1)}{14(14-1)}+\frac{2(2-1)}{14(14-1)}+\frac{2(2-1)}{14(14-1)}\right)=0.06$$

Species 1= *Macrocheles robustulus*; $n_1$=8(♀)
Species 2= *Macrocheles muscaedomesticae*; $n_2$=2(♀)
Species 3= *Macrocheles scutacus*; $n_3$=2(♀)
Species 4= *Parasitus coleoptratorum*; $n_4$=2(DN)

**Biodiversity Estimation of the Species Collected in Poultry Manure:** Finally 4 mesotigmatic mite species from 2 different families were found in association with *E. gibbosus* and *Geotrupes* sp. beetles in poultry manure. The lists of the phoretic mite species and their beetle hosts are written below:

Macrochelidae
*Macrocheles glaber* [*E. gibbosus*]
*Macrocheles muscaedomesticae* [*Geotrupes* sp.]
*Macrocheles subbadius* [*Geotrupes* sp.]

Parasitidae
*Parasitus coleoptratorum* [*E. gibbosus*]

Biodiversity estimation on *E. gibbosus*:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{12(12-1)}{19(19-1)}+\frac{7(7-1)}{19(19-1)}\right)=0.49$$

Species 1= *Macrocheles glaber*; $n_1$=12(♀)
Species 2= *Parasitus coleoptratorum*; $n_2$=7(DN)

Biodiversity estimation on *Geotrupes* sp.:

$$1\text{-}\hat{D}=1\text{-}\sum_{i=1}^{S}\left[\frac{n_1(n_1\text{-}1)}{N(N\text{-}1)}\right]=1\text{-}\left(\frac{5(5-1)}{7(7-1)}+\frac{2(2-1)}{7(7-1)}\right)=0.48$$

Species 1= *Macrocheles muscaedomesticae*; $n_1$=5(♀)
Species 2= *Macrocheles subbadius*; $n_2$=2(♀)

## DISCUSSION

During this study, totally 37 species from 21 genera, 12 families and 7 superfamilies of Mesostigmata have been collected from 16 different host species of adult beetles. The majority of the beetles (12 species) belonged to the family Scarabaeidae. One carabid, two cerambycids and one buprestid were also among the beetle hosts. Necessary to say that many samplings have been done on other Coleoptera families. For example, many beetles from the families Tenebrionidae, Coccinellidae, Hydrophilidae, Curculionidae and Staphylinidae have been studied but only astigmatic (mostly hypopus) and some times oribatid and prostigmatic species have been collected. In our studies, one larva of Ixodidae (Metastigmata) has also been removed from a male beetle of the species *Oryctes nascicornis* in Shast-kola forest. Probably it is a casual phoretic or maybe it acts as an ectoparasite on the beetle host. The greatest number of phoretic mites, 18 species, was removed from the beetle *Euonthophagus gibbosus*. Among the studied dung beetles, this species of Coleoptera has also the highest biodiversity of phoretic Mesostigmata. After this beetle species, *Geotrupes* sp. and *Herpalus* sp. were the hosts for respectively 7 and 6 mesostigmatic mite species. Among Mesostigmata families, Macrochelidae with 12 species has the highest diversity which the majority of them were found associated with dung beetles. According to data acquired in this research and literature review of earlier studies that have been conducted around the world, it seems that among these species *Weiseronyssus persicus* and *Copriphis* cf. *Meyeri* are monoxenics and have host specificity. *Uropoda copridis*, *Neopodocinum caputmedusae*, *Coleolaelaps costai*, *Hypoaspis phyllognathi* and *Anystipalpus livshitsi* are oligoxenics while other collected species especially *Macrocheles* and *Parasitus* species are polyxenics. It seems that phoretic mites in some particular families are associated with certain families of Coleoptera, for example the phoretic mites of the family Ascidae like different species of *Antennoseius* and *Anystipalpus* are associated only with the family Carabidae [91, 92, 93]. In polyxenic species, it seems that habitat is more important for phoront mites than the host species itself and they are associated with the beetle species that live or are available in these habitats in the critical times. Most of these polyxenic mite species live in animal manure or decaying organic substrates. For example in this study, different species of *Macrocheles* had no phoretic specificity and they were found almost on every host that live in their habitat includings scarab beetles and also they have been reported from different families of Diptera that also live in dung habitat. In animal manure predator staphylinid beetles were found abundantly but no mites were collected from them. Maybe it is because of staphilinids are very fast running but mites are very slow moving and

perhaps these mites can not attach them and despite of many samplings no mites were collected in association with these beetles. In our samplings only one female of *Gaeolaelaps aculeifer* and two females of *G. nolli* were collected from the beetle hosts. In the previous studies on phoresy, there is no report of phoretic relationship in *G. aculeifer* and there are only a few reports of phoresy in *G. nolli*. It seems that these two mite species are causal phoretics.

Regarding to the data obtained in our study and the previous investigations, among the collected mite species *Weiseronyssys persicus* and *Pachylaelaps pectinifer* are only recorded in humid and temperate regions in north of Iran. The other removed species have high adaptations with different climates and have been recorded from humid, semi-arid and arid regions.

In the families Diplogyniidae and Pachylaelapidae, adult females and males disperse through phoresy, in other words the adults are the phoretic stages. In these phoretic mites, after arriving at suitable habitat females and males mate and then reproduction takes place and large numbers of progeny will be produced. In Macrochelidae the phoretic stage is the adult female. The majority of the females have fully grown eggs. These females lay their eggs in the new environment which the situations are favorable for the the adult females or their progeny. In the collected species of Laelapidae, Ascidae and Ameroseiidae, female is also the phoretic stage, but none of the removed mites have eggs in their bodies. So it can be concluded that reproduction in the new loci occurs through parthenogenesis. In some other groups or families collected in this research deutonymphs are the phoretic stages included Uropodoidea, Halolaelapidae and Parasitidae. In these mites, deutonymphs will develop into adults in the new better environment and then mate and reproduce. In different species of the family Eviphididae including *Metacryptoseius persicus*, *Copriphis* cf. *Meyeri* and *Scarabaspis inexpectatus* and also in macrochelid species *N. caputmedusae*, all of their life stages were found in association with the hosts. As protonymphs can not attach to the hosts easily it can be concluded that these mites can mate and reproduce on the host.

Phoronts attach to different parts of hosts' bodies. Mites of Uropodoidea cling to hosts through anal pedicel and are sedentary on the hosts and have no feeding and reproduction according to the basic definition of phoresy [3]. All life stages of *Copriphis* cf. *Meyeri* were found abundantly in the gular area of *S. transcaspicus* and probably they feeds on the thin membrane layer of the beetle's gular area. In species like *Uropoda copridis* and *Neopodocincum caputmedusae* which attach to the mouthparts of the hosts in large numbers, maybe they could cause some problems in the hosts' feeding. As nematophagy is commom in Uropodidae and Macrochelidae, *U. copridis* and *N. caputmedusae* as a member of these two families may feed on the microorganisms like nematodes existing in the beetle hosts' food resource. Also when phoretic mites in large numbers attach to the hosts it can result in slowing down the hosts flying or movement. In the family Parasitidae the phoretic mites are very active on the body of the carriers and they move very fast. These mites can prey on microarthropods and in some cases they prey on nematods on the body of hosts or even preying the hosts' eggs [72, 94].

From the phylogenetic aspect, *N. caputmedusae* is different from other macrochelid species collected in this study in different morphological and behavioral characteristics. The morphological characters of this species including large body size, hypertrichy and even long marginal setae and also some behavioral characters i.e. the habit of phoresy (which is a primitive character) indicate this species belongs to lower taxa. Although some advanced behavioral characters i.e. oligoxeny (in comparison with most polyxenic macrochelid species) and even the ability of reproducing on the host carrier are found in this mite species. There is an apparent affinity between the genus *Neopodocinum* and the family Pachylaelapidae in both morphological and behavioral characteristics. Maybe *Neopodocinum* is an intermediate group between Macrochelidae and Pachylaelapidae, or maybe similar morphological charactes have evolved independently in *Neopodocinum* and Pachylaelapidae, but the convergence is the result of similar behavioral and habitat patterns. The latter theory is more probable [95].

Biodiversity samplings conducted on dung beetles and different kinds of livestock manure. In these samplings, the beetles and the phoretic Mesostigmata have the most abundancy on cow dung and also in different kinds of manure *Euonthophagus gibbosus* was the most frequent host and also the greatest number of phoretic Mesostigmata has been collected from this beetle species. The least number of beetles and phoretic mites were obtained in poultry manure, maybe it is because of hygienic exercises that carried out in poultries. In other words, poultry manure being thrown out every day and so finding beetles and phoretic mites is very difficult. In the whole, the most phoretic Mesostigmata were removed from manures with medium humidity, not very fresh and not very old.

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