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Survey and population fluctuation of mites inhabiting different manures from Makkah region in Saudi Arabia

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Abstract
Mites occupying manures are of great biological importance such as predacious mites. Recently, awareness has been given to soil fauna especially mites because of their sensitivity to different insecticides used in pest control. The present research was carried out to study the population density of mites inhabiting three types of manure such as cattle, sheep, and poultry collected from different farms from Makkah region in Saudi Arabia for one year from January to December 2020. Survey study revealed the presence of 51species belonging to 27 families and 4 suborders of mites, Acaridida, Actinedida, Gamasida, and Orabitida. Results indicated that Suborder Acaridida was represented by 5 species belonging to 4 families. As well, Suborder Actinedida was represented by 22 species belonging to 11 families. Besides, Suborder Gamasida was presented by 22 species belonging to 10 families, while Suborder Oribatida was presented by 2 species belonging to 2 families. Suborder Acaridida recorded the highest number of individuals (503.3) followed by Actinedida (129.6) and Gamasida (60.05), while Suborder Oribatida represented the lowest number (2.60). Manures are good habitats for the natural rearing of different species of predacious mites which could be beneficial in biological control programs.

Keywords: survey, population density, mites, manures

Introduction

Manures of domestic animals and poultry are proper habitations for very large cosmopolitan groups of predators and scavenger mites, as for dung-reproducing Dipterous species such as *Musca domestica* Linnaeus and many other dipterous which lay their eggs on animal feces. Some previous studies mentioned the ability of Mesostigmatid mites inhabiting manure in monitoring Arthropods population such as flies in livestock manures (Halliday and Holm, 1987; Axtell, 1990; Minor and Norton, 2004; Kazemi and Rajaei, 2013) [6, 30, 26].

Manures of domestic animals rich in minerals have been used for over two millennia as organic fertilizers to increase plant growth and crop quality. It has been improving the chemical and physical properties of soil (Pizzeghello *et al*., 2011) [32]. Usually, rations with high moisture and low protein content especially during the spring season, lead to increase Diptera and decrease mite densities. Manure used in soil fertilization contains different mites. Predacious mites are important factors in biological control against nematodes and some Dipteran species inhabiting soil (Afifi *et al*., 1986; Glida *et al*., 2003; Mowafi, 2005) [2, 21, 31].

Krantz (1983), reported that Arthropoda found in animal manures represent a diverse fauna, where considerable mite species corresponding to 25 families of Acari exist as parasites, fungivores, detritivores, and bacteriophages in dung substrates. Furthermore, Fouly and Rehiayani (2011) [20], collected 31 species of mites from plant shoot, root and different manure samples from diverse sites in Al-Qassim region and they declared the occurrence of mites was 6.46%, 25.8% and 67.74 % for Acarid, Actenidid and Gamasid, respectively.

Stored animal manure makes a diverse substrate, with numerous microhabitats available to the arthropods therein (Lindquist *et al*., 2009 and Arjomandi *et al*., 2013) [29, 5]. Acharya and Datta (2019) [1], reported 23 species of oribatid mites belonging to 18 genera and 16 families in Himachal Pradesh, India. Walter and Proctor (2013), expressed the high abundance of Oribatid mites in soils. Therefore, explaining their environmental value in decomposing the soil organic matter, formation and changing in the soil properties, and also supporting plants with nutrients (Wasilewski 2006; Walter and Proctor 2013) [39].

On the other hand, the family Parasitidae includes valuable species that are found in litter and humus, some of which are particularly present in organic material-gathering such as decaying seaweed, dung, compost, and in the underground nests of small mammals (Hyatt, 1980; Karg, 1993; Blackman, 1997) [25, 11]. Mites in the family Parasitidae are primarily predators of microarthropods and nematodes living in soil and spread during their deutonymphal stage on insects (mainly Coleopteran and Hymenopteran) (Beaulieu *et al*., 2011) [9]. Amitai (1992) [4], declared that predatory mites have a significant role in controlling pest populations living in diverse habitats. Hence some predator mite species are utilized in Biocontrol approaches in several countries (Fouly *et al*., 1997; Takano-Lee and Hoddle, 2002) [35]. Useful areal and mites inhabiting soil mainly predacious species should be preserved in the field to promote a secure pest and natural balance since mites display different relationships with other creatures (Walter and Campbell, 2003; Heckmann *et al*., 2007) [38,].

Several studies proposed the Acarid mites as promising eco-friendly agents for managing nematode that parasites plant (Sell, 1988; Walia and Mathur, 1995) [34,]. Such as the Acarid mites *Caloglyphus manure* Eraky, that preys on plant parasite nematode (Eraky and Osman, 2008). Moreover, Karagoz *et al.* (2007), reported that *Sancassania*

sp. feeds on eggs, juveniles and females of the nematode *Meloidogyne spp.*, while *Tyrophagus putrescentiae* (Schand) and *Hypoaspis calcuttaensis* predate on juveniles and egg masses of *M. javanica* (Walia and Mather, 1995). Arjomandi *et al*. (2013) [5], mentioned that mite populations could be affected by pesticide application, which affects their longevity and reproduction. Moreover, Elmoghazy and Shawer (2013) [15], also stated that the environment of soil organisms in managed ecosystems can be affected by soil use factors, such as cultivation, insecticides and composts use, soil compaction during harvest, and removal of plant biomass.

Ominously, agronomic strengthening such as increasing pesticide usage, basic environments, perturbed habitats, has endangered Natural enemy populations and restricted biological management services (Begg *et al*., 2017) [10]. Hence, there is growing interest in-field habitation strategies, including reduced cultivation, decreased insecticide treatment, higher diversity establishing (including cover crops), covering, or fertilizing with organic matter-rich variations, such as manure, to support natural enemies (Rusch *et al.*, 2017; Alyohkin *et al.*, 2020; Tooker *et al*., 2020) [33, 3, 36]. Manure mites have great biological importance both in natural and cultivated soils. Therefore, the present study aimed to investigate the fauna and diversity of manures-inhabiting mites of three different farms from Makkah region and to shed light on the importance of these species and their sensitivity to different insecticides used in agriculture.

Materials and Methods

The current study was carried out on some private farms from Makkah Region in Saudi Arabia for one year from January to December 2020.

Collection of mites:

Samples of manures 500gm each were collected monthly from three different farms such as cattle, sheep, and poultry. All samples were replicated three times, put in a plastic bag with labels including the type of manure and the date of collection, then transferred on the same day to the Biological laboratory of Jeddah University for the extraction process.

Extraction and Identification of Mites

The collected manure samples were placed in Tullgren funnels on a wire screen insert (30 cm diameter, 6 meshes opening), a 40-watt electric bulb on top of each funnel served as a heat and light source to drive the arthropods downward into a 100 ml glass beaker containing 70% ethyl alcohol.

Samples were left on the funnels for 72 hours. Contents of the glass beaker were transferred to screw-capped tubes, where mite individuals were counted and examined using a dissecting stereomicroscope.

The extracted individuals from Suborders (Acaridida, Actinedida, Oribatida, and Gamasida) were counted and isolated from the extracted mixture. Mites of each sample were transferred to another small beaker using a fine-tipped camel hairbrush under a dissecting stereomicroscope, a drop of lactic acid was added, covered with a plastic cover, and left for 7 days to be cleared up.

Mites were mounted in Hoyer's medium on glass slides according to Grandjean (1949). Permanente specimens were dried at 50°C for 3 - 4 days. A label was placed on each slide with the type of manure and the date of collection.

Specimens were identified and classified taxonomically according to Mahunka (1972), Krantz (1978) [27], Balogh and Mahunka (1983) [8] and Zaher (1986) [40].

Statistical Analysis

Data were subjected to the analysis of variance test (ANOVA) as randomized complete blocks design. The least significant differences (LSD) at the 5% level were determined using a computer program CoStat, version 6.311 (2008), and Duncan's Multiple Range testes and LSD 5% values were used to compare the average mean numbers.

Results

Survey study

The Survey of the present study identified 51 species of 37 genera and 27 families belonging to suborders; Acaridida, Actinedida, Gamasida and Oribatida.

Suborder: Acaridida

Data in table (1) indicated that suborder Acaridida was represented by 5 species in 4 Families: Acaridae, Glycyphagidae**,** Saproglyphidae, and Scatoglyphidae.

Table 1: Classification of Acaridida mite species associated with three types of manures from Makkah Region.

Family	Taxa species	Cattle	sheep	poultry
1-Acaridae (Ewing & Nesbitt, 1954)	*Rhizoglyphus echinopus* (Schrank, 1781)	+	+	+
	Tyrophagusutrescentiae (Fumouze & Robin,1868)	+	+	+
2-Glycyphagidae	*Glycoglyphus domesticus* (De Geer)	-	-	+
3 Saproglyphidae	*Saproglyphus* sp.	+	-	-
4-Scatoglyphidae	*Scatopglyphuspolytrematus* (Berlese, 1913)	-	-	+

Suborder: Actinedida

As shown in table (2), data indicated that suborder Actinedida was presented by 22 species in 11 Families: Bdellidae, Caligonellidae, Cheyletidae, Cunaxidae, Microdispidae, Microtrombidiidae**,** Pygmyphoridae, Scutacaidae, Siteroptidae, Stigmaidae and Tarsonemidae.

Table 2: Classification of Actinedida mite species associated with three types of manures from Makkah Region.

Family	Taxa species	cattle	Sheep	poultry
1. Bdellidae (Duges,1834)	*Spinibdella bifurcate* (Atyeo)	-	-	+
2. Caligonellidae (Grandjean, 1944)	*Molothrognathus sp.*	-	-	+
3. Cheyletidae (Leach, 1815)	*Acaropsella* sp.	-	-	+
	Cheyletus malaccensis (Oudemans,1903)	+	+	+
	Cheyletogenes ornatus (Canestrini and Fanzago, 1876)	-	-	+
	Ker bakeri (Zaher and Soliman1967)	-	-	+
	Ker sp.	-	-	+

4. Cunaxidae (Thor, 1902)	*Coleoscirus breslauensis* (Den Hayer)	+	+	+
	Coleoscirus buartsus (Den Hayer)	+	+	+
	Cunaxa rahis (Den Hayer)	-	-	+
	Cunaxa sp.	+	-	-
5. Microdispidae	*Brennandania silvestris* (Jacot,1936)	+	+	+
6. Microtrombidiidae	*Microtrombidium sp*	+	-	-
7. Pygmyphoridae (Cross *et* Mahunka, 1969)	*Pediculaster mesembrinae (Canestrini,1881)*	+	+	+
	Pediculaster monoufiensis (Sevastianov *et* Abo-Korah 1985)	-	+	+
	Pediculaster sp.	+	+	+
	Bakerdania tarsalis (Hirst,1921)	-	+	-
8. Scutacaridae (Oudeman, 1916)	*Scutacarus sp.*	+	-	-
9. Siteroptidae (Mahunka)	*Siteroptes sp.*	+	-	-
10. Stigmaeidae (Oudemans, 1931)	*Storchia robustus* (Berlese, 1885)	-	-	+
	Apostigmaeus aegyptiacus (Soliman *et* Gomaa,1986)	+	-	+
11. Tarsonemidae (Kramer, 1877)	*Tarsonemus sp.*	+	+	+

Suborder: Gamasida

Data in table (3) indicated that suborder Gamasida was presented by 22 species in 10 families: Ameroseiidae, Ascidae, Degamasellidae, Dermanyssidae, Laelapidae, Macrochelidae, Melicharidae, Parasitidae, Sejidae and Uropodidae.

Table 3: Classification of Gamasida mite species associated with three types of manures from Makkah Region.

Family	Taxa species	Cattle	Sheep	Poultry
1. Ameroseiidae (Evans, 1963)	*Ameroseius kosi* (Elbadry, Nasr *et* Hafez,1979)	-	-	+
	Ameroseius plumosus (Oudemans, 1902)	+	-	+
	Ameroseius wahabi	-	-	+
2. Ascidae (Voigts and Oudeman)	*Protogamasellus biforcalis* (Loots and Ryke,1967)	+	-	+
3. Degmasselidae (Evans, 1957)	*Dendrolaelaps* sp	-	-	+
4. Dermanyssidae (Kolenati, 1859)	*Dermanyssus gallinae* (De Geer, 1778)	+	-	+
5. Laelapidae (Berlese, 1892)	*Androlaelaps aegyptiacus* (Elbadry and Nasr,1982)	+	+	+
	A. casalis(Berlese, 1887)	+	-	+
	A. zaheri (Elbadry and Nasr,1982)	+	+	+
	Geolaelaps orientalis (Hafez,Elbadry,Nasr)	+	-	+
6. Macrochelidae (Vitzhum, 1930)	*Macrocheles africanus* (Hafez, Elbadry, Nasr,1985)	-	-	+
	M. matrius (Hull,1925)	+	-	+
	M. merdarius (Berlese,1889)	+	+	+
	M. Muscadomesticae (Scopoli, 1772)	+	+	+
7. Melicharidae (Hirschmann, 1962)	*Proctolaelaps gizaensis* (Abo-Shnaf et Moraes,2016)	-	-	+
	Proctolaelaps pygmaeus (Maller, 1859)	-	-	+
8. Parasitidae (Oudemand, 1901)	*Cornigamasus ocliferius* (Skoupski *et* Witalinski,1997)	+	-	+
	Parasitus consanguineous (Oudeman&Voigts, 1904)	+	-	+
	Parasitus fimetorum (Berlese,1903)	+	-	+
9. Sejidae (Berlese, 1885)	*Sejus baloghi* (Athias-Henriot 1960)	+	+	+
10. Uropodidae (Kramer, 1881)	*Urobovella* sp. (Berlese, 1903)	+	+	+
	Urodinychus sp.	+	+	+

Suborder: Oribatida

Data in table (4) indicated that suborder Oribatida was presented by 2 species in 2 Families: Opiidae and Ctenacaridae. Results revealed that Families; Cheyletidae, Laelapidae, Macrochelidae, Pygmyphoridae represented the majority of species, also family Acaridae occupied the first rank in numbers and population followed by family Cheyletidae and Laelapidae.

Table 4: Classification of Oribatida mite species associated with three types of manures from Makkah Region.

Family	Taxa species	cattle	sheep	poultry
1-Opiidae (Grandjean,1954)	*Multioppia wilsoni* (Aoki,1964)	-	+	+
2-Ctenacaridae (Grandjean,1954)	*Ctenacarus sp.*	+	+	+

Population Density

The population abundance of the suborders (Acaridida, Actinedidae, Gamasida, and Oribatida) inhabiting three types of manures (cattle, sheep, and poultry) in Makkah Region were studied for 12 months during the year 2020.

Suborder: Acaridida

Results in Table (5) showed the population abundance of Acaridida and Actinedida mites inhabiting three types of organic manures during 2020.

As shown in table (5), the average numbers of Acaridida mites examined in the three different manures, was 321.1, 7.2 and 306.9 individuals/1kg for cattle, sheep and poultry, respectively. Results indicated that there were significant differences between the mite numbers in both cattle, poultry and sheep manures (LSD 5% = 163.1), while there were no significant differences between cattle and poultry manures.

As for the population abundance of Acaridida mites along 12 months, results in Table (5) revealed that the highest numbers were recorded in the month of June as 1487.6 individuals/kg followed by January as 1198.6 individuals/1kg, while the lowest numbers were recorded during the months; September, November, October, and August: 41.6, 48.7, 70.3 and 93.0 individuals/1kg, respectively without significant differences (LSD 5% = 503.3).

Suborder: Actinedida

The average numbers of Actinedida mites from different manures were 56.9, 17.5 and 74.5 individuals/1kg for cattle, sheep and poultry, respectively. Results in Table (5) indicated that there were significant differences in the mite numbers between the three tested manures (LSD 5% = 8.6).

While for the population abundance of Actinedida mites along different months of the year 2020, results revealed that the highest numbers of mites were recorded in November as 834.3 individuals/1kg followed by June and July recording 491.2 and 548.3 individuals/1kg, respectively with significant differences (LSD 5% = 129.6), while no Actinedida mites were observed during March and April.

Table 5: Population abundance of Acaridida and Actinedida mites inhabiting three types of manures from Makkah Region.

Months 2020	Average no. of mites suborders /1 kg manure							
	Acaridida			Total	Actinedida			Total
	Cattle	Sheep	Poultry		Cattle	Sheep	Poultry	
January	1105.3	6.0	87.3	1198.6^{ab}	88.3	27.3	12.7	128.3^{d}
February	1017.7	11.3	44.3	1073.7^{ab}	51.0	13.3	19.3	83.6^{d}
March	713.0	0.0	00.0	713.0^{b}	0.0	0.0	0.0	0.0^{d}
April	807.3	0.0	0.3	807.3^{b}	0.0	0.0	0.0	0.0^{d}
May	102.0	0.0	00.0	102.0^{c}	0.7	0.0	13.7	14.4^{d}
June	37.3	0.0	1450.3	1487.6^{a}	37.3	3.6	450.3	491.2^{bc}
July	44.3	3.3	900.7	948.3^{b}	71.0	107.3	370.0	548.3^{b}
August	0.0	39.7	53.3	93.0^{c}	13.3	50.6	13.0	76.3^{d}
September	0.0	11.3	30.3	41.6^{c}	0.0	0.3	17.0	17.3^{d}
October	13.3	2.0	55.0	70.3^{c}	0.0	0.0	110.3	110.3^{d}
November	11.0	0.0	37.7	48.7^{c}	112.3	0.0	730.0	842.3^{a}
December	7.0	13.0	1000.7	1020.7^{ab}	309. 3	8.3	100.3	417.9^{c}
Total	3853.2	86.6	3682.9	7604.8	683.63	210.7	1836.6	2730.0
Mean	321.1^{A}	7.2 ^{B}	306.9 ^{A}	633.7	56.9 ^{B}	17.5 ^{C}	74.5 ^{A}	227.5
LSD 5% (months)				503.3				129.6
LSD 5% (manure types)				163.1				8.6

Means in the column or the row followed by different letter(s) are significantly different at 5% level

Suborder: Gamasida

Results in Table (6) showed the population abundance of Gamasida and Oribatida mites inhabiting three types of organic manures during 2020. The average number of Gamasida mites from different manures was 33.5, 4.5 and 22.0 individuals/1kg for cattle, sheep and poultry farms, respectively. Results in Table (6) indicated that there were significant differences in the mite numbers between the three tested manures (LSD 5% = 14.3).

The population abundance of Gamasida mites during different months of the year 2020, recorded the highest numbers of mites in April and November: 146.3 and 161.7 individuals/1kg, respectively without significant differences (LSD 5% = 32.3), while the lowest numbers were recorded in July as 3.3 individuals/1kg with significant differences.

Sub Order: Oribatida

The average number of Oribatida mites from different manure types, was 0.9, 0.6 and 1.1 individuals/1kg for cattle, sheep and poultry samples, respectively. Results in Table (6) indicated that there were significant differences between the mite numbers in tested manures (LSD 5% = 0.34).

While for the population abundance of Oribatida mites along different months during 2020, results in Table (6) revealed that the highest numbers of mites were recorded in November as 14.3 individuals/1kg, while no individuals were recorded in March and May 3.6 and 3.3 with significant differences (LSD 5% = 1.2), and no mites were observed during January, June and September.

Table 6: Population abundance of Gamasida and Oribatida mites inhabiting three types of manures from Makkah Region.

Months 2020	**Average no. of mites suborders /1 kg manure**							
	Gamasida			**Total**	**Oribatida**			Total
	Cattle	**Sheep**	**Poultry**		**Cattle**	**Sheep**	**Poultry**	
January	6.3	6.0	13.3	25.6^{def}	0.0	0.0	0.0	0.0^{e}
February	0.0	3.7	31.6	35.3d^{e}	2.0	0.0	0.3	2.3^{cd}
March	19.3	0.0	46.0	65.3^{cd}	1.6	0.0	2.0	3.6^{b}
April	33.7	0.0	112.6	146.3^{a}	2.0	0.0	0.0	2.0^{d}
May	33.0	6.0	23.3	62.3^{bc}	0.0	0.0	3.3	3.3^{bc}
June	31.3	1.3	0.0	32.6^{def}	0.0	0.0	0.0	0.0^{e}
July	0.0	3.3	0.0	3.3^{f}	0.0	1.6	0.0	1.6^{d}
August	47.0	0.0	0.3	47.3^{cd}	0.3	2.0	0.0	2.3^{cd}
September	0.3	12.7	0.0	13.0^{ef}	0.0	0.0	0.0	0.0^{e}

October	62.0	16.0	6.0	84.3[b]	1.6	0.0	0.0	1.6[d]
November	157.7	3.6	0.7	161.7[a]	3.3	3.7	7.3	14.3[a]
December	11.7	1.3	30.3	43.3[cd]	0.0	0.0	0.3	0.3[e]
Total	402.3	53.9	264.1	720.3	10.8	7.3	13.2	31.3
Mean	33.5 [A]	4.5 [C]	22.0 [B]	60.05	0.9 [AB]	0.6 [B]	1.1 [A]	2.60
LSD 5% (months)				32.3				1.2
LSD 5% (manure types)				14.3				0.34

Means in the column or the row followed by different letter(s) are significantly different at 5% level

Discussion

Results of the current study agree with previous studies conducted by Fernandes, *et al*. (1995) [19]; Badejo, *et al.* (2004) [7]; Minor and Norton (2004) [30]; El-Shazly, *et al*. (2011) [16] and Horn, *et al*. (2016) [24], where they studied the ecology and evaluation of several Acari suborders inhabiting a variety of small and big animal farms in different localities of the world.

In the present study, predatory mites were recorded in the samples collected from three different manures, similar results revealed the presence of several predators and ectoparasitic mites from different manures (Arjomandi *et al*., 2013) [5]. Also, De Silva *et al*.(2009) [14], declared that the number of predacious mites such as Cheyletidae, Laelapidae and Macrochelidae recorded a high value in the poultry house of Teutonia.

The result of the present survey is in agreement with Fouly and Rehiayani (2011) [20], who declared the presence of some Gamasid mites collected from organic manures such as *Macrocheles merdarius*, *M. Muscadomestica*, *Rhodacarus roseus* and *Leiodinychus* sp. since similar species including *Macrocheles merdarius* and *M. muscadomesticae* were collected from the three different manures studied (cattle, sheep and poultry).

Faraji and Halliday (2009) [18], revealed that Laelapid mites are free-living predators observed in numerous environments related to vertebrates and invertebrates which supports the results of the present study where Laelapid mites were found in most farms' samples.

The current survey indicated the presence of two species of the Suborder Oribatida (Opiidae and Ctenacaridae) which insure previous records that these species play a vital role in modifying the soil properties decomposing the organic substance of the soil, hence supporting plants with nutrients (Walter and Proctor 2013, Bluhm *et al*., 2015) [12].

Conclusion

It is of importance to realize the mite fauna in different manures where phytophagous and predacious mites could be found. Applying such manures as fertilizers to crops should be free of phytophagous pests. These manures are convenient media for rearing different species of predacious mites which could be beneficial in biological control programs.

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