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BIODIVERSITY OF SOIL ORIBATID MITE (ACARI : ORIBATIDAE) IN DIFFERENT AGRO-ECOSYSTEMS

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ABSTRACT : Biodiversity of oribatid mites were investigated in different disturbed and undisturbed soil of orchards, vegetables, field crops, greenhouse, forest plants, organic farm, bio-diversity park, spices crops, vermicompost bed, ornamental and medicinal plants in Navsari Agricultural University campus during the year 2018 and 2019. Among 3 suborders Brachypylina contributed 66 per cent of total species recorded in Navsari Agricultural University campus. Total 8 species of the suborder Brachypylina were recorded on different agro-ecosystem and fallow land. Out of all 12 species, the proportion of *S. curvialatus* was highest (20.67%) and was followed by *Scheloribates* sp. (15.77%), *O. kuehnelti* (14.95%), *S. huancayensis* (10.21%) and *J. kuehnelti* (10.05%). Maximum numbers of oribatid species were recorded during August-November and moderate population was observed in June-July months during the survey period in different agro-ecosystems. The value of Shannon index of diversity for oribatid mites at Navsari Agricultural University campus is 2.2340 and value of Simpson's index is 0.1253, evenness of oribatid mite species was 0.6650 while, species richness is 12.

Key words : Oribatid mites, biodiversity, species richness.

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INTRODUCTION

The soil is a reservoir of biodiversity (André *et al*, 2002; Coleman and Whitman, 2005; Ritz *et al*, 2009) and is even considered by some ecologists and geneticists as the biggest biodiversity reservoir on earth (Feeney *et al*, 2006 and Lescroart, 2009). Due to multiple reasons, our knowledge about the soil fauna and in particular on soil mite is very poor (André *et al*, 1997 and Giller *et al*, 1997). Soil mites are an important component of the ecosystem, because of their relevant role as regulators of key functional processes (Lavelle, 1996; Andrén and Balandreau, 1999; Fitter *et al*, 2005; Palacio-Vargas *et al*, 2007; Bardgett, 2008). Generally, they contribute to organic matter decomposition and mineralization (Santos and Whitford, 1981; Seastedt, 1984; Whitford and Parker, 1989; Tian *et al*, 1998; Joo *et al*, 2006; Wang *et al*, 2009) and regulation of microfauna and microflora (Seastedt, 1984; Lavelle and Spain, 1991; Gobat *et al*, 2004). As the macrofauna, the soil mite community is often considered to be a useful bioindicator of ecosystem conditions and changes (Lebrun and Van Straalen, 1996; Van Straalen, 1998; Parisi *et al*, 2005; Tondoh *et al*, 2007). Mites in soil are generally represented by four major groups viz., Prostigmata, Astigmata, Mesostigmata and Oribatida. Among four major groups, Oribatid mites belong to the suborder Cryptostigmata (oribatida). Since these mites are dark-colored and covered with a rigid exoskeleton, they are popularly known as 'beetle' or 'moss' mites and are the world's most numerous arthropods living in the soil. The adult oribatid mites usually have a strong exoskeleton, hardened by sclerotization as in other mites and by mineralization, similar to millipedes and isopods. These slow-moving mites are 0.2-1.0 mm in length and occur in the top layer of soil, litter debris, sometimes also on plants, mosses and lichens. In soil, oribatid mites constitute more than 50 per cent of the total micro-arthropod population. Their densities range from 50,000 per m2 in tropical to 3,00,000 per m2 in boreal forests where a large amount of organic matter occurs. They also selectively feed on microflora adhering to this detritus. Oribatid mites are known only from seven states of India, viz., West Bengal, Bihar, Orissa, Uttar Pradesh, Tamil Nadu, Kerala and Sikkim. The other Indian states are completely unexplored in so far as the mites of this

group are concerned. Some work on taxonomy, biology and ecology of soil mites has been made in India, but the biodiversity on these mites have been neglected which is needed to be studied.

MATERIALS AND METHODS

Study sites : The study sites were located within the Navsari Agricultural University Campus, South Gujarat (Fig. 1). Different agro-ecosystems of Navsari Agricultural University, Navsari campus and nearby areas were comprehensively surveyed for the collection of soil mites from different disturbed and undisturbed soil fauna of orchards, vegetables, field crops, greenhouse, forest plants, ornamental and medicinal plants, etc. during the year 2018 and 2019. The soil and litter samples from the

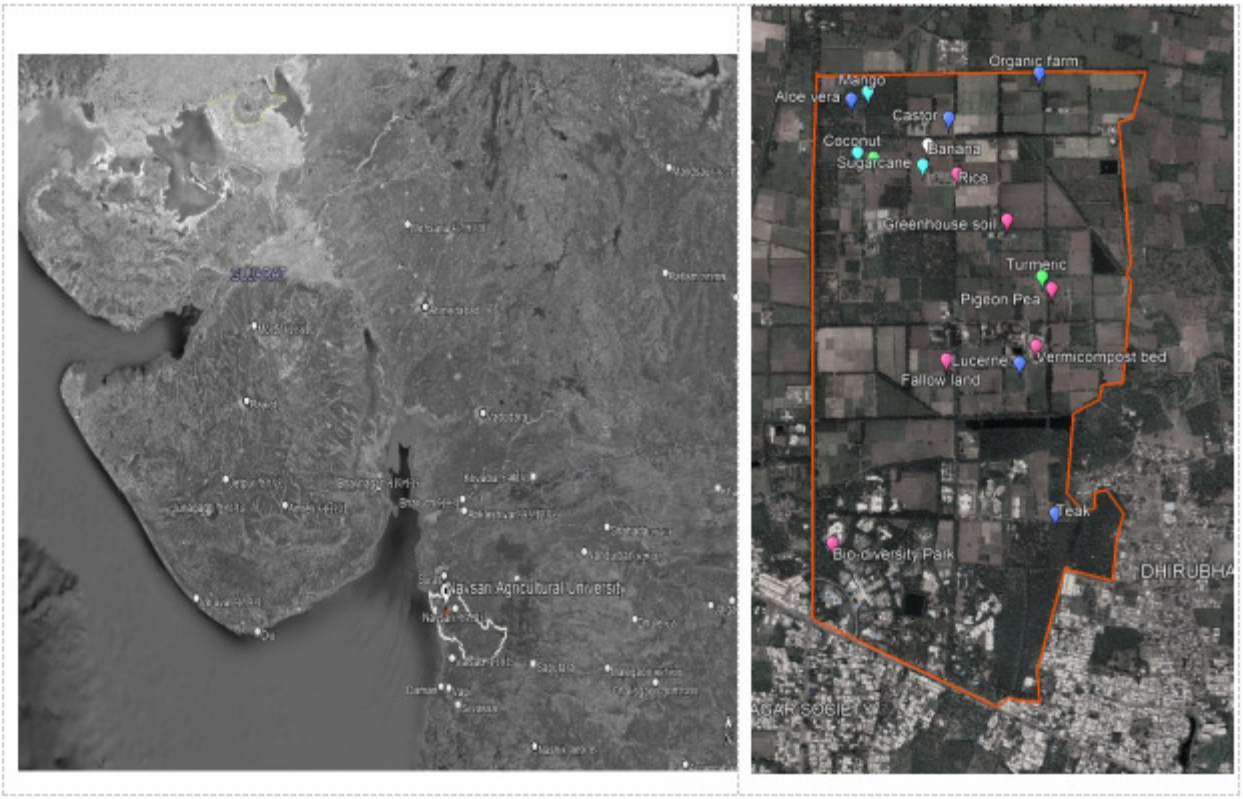

Fig. 1 : Study sites in the Navsari Agricultural University, South Gujarat, India.

various sites described above were collected from five different sites per plots with three different depths (0-5 cm, 5-10 cm, 10-15 cm). Sampled soil was brought to the Acarology laboratory in individually labeled polythene bags (500 gm) tied with rubber band. The process of extraction was carried out in an open brass funnel apparatus following the extraction principles of Berlese (1905) and Tullgren (1918). These samples were properly labelled and kept in plastic vials having alcohol (90%) with tightly closed caps for further studies. The mites thus collected, were mounted on glass slides by using Hoyer's media.

Biodiversity analysis : For making biodiversity analysis, the data regarding collected specimens of soil mites were arranged according to source during each season of collection. The averages were worked out. There are different methods to calculate the species diversity. The biodiversity count was made by using Shannon diversity index (Shannon, 1948) to estimate species richness, evenness and species diversity (Shannon Weiner Diversity Index). The per cent proportion of different soil oribatid mite species was determined and percentage of each species was calculated. This analysis was made to determine the most abundant and prevalent soil mite species in the region during the survey.

RESULTS AND DISCUSSION

Among 3 suborders Brachypylina contributed 66 per cent of the total species recorded in Navsari Agricultural University campus. Total 8 species of the suborder Brachypylina were recorded in different agro-ecosystems and fallow land. These 8 species were belonging to 4 families *viz*., Scheloribatidae, Haplozetidae, Oppiidae and Mochlozetidae and 6 different genera *viz*., *Scheloribates* (3 species), *Protoribates* (1 species), *Rostrozetes* (1 species), *Oppia* (1 species), *Amerioppia* (1 species), *Unguizetes* (1 species), respectively were also recorded during the survey (Table 1). The proportion of different

Table 1 : Soil oribatid mite diversity during year 2018 and 2019.

Suborder	Family	Genera	Species number
Brachypylina	Scheloribatidae	*Scheloribates*	3
	Haplozetidae	*Protoribates*	1
		Rostrozetes	1
	Oppiidae	*Oppia*	1
		Amerioppia	1
	Mochlozetidae	*Unguizetes*	1
Mixonomata	Lohmanidae	*Javacarus*	1
	Euphthiracaridae	*Rhysotritia*	1
Poronoticae	Ceratozetidae	*Trichoribates*	1
	Galumnidae	*Galumna*	1
Total			12

Table 2 : Proportion of different oribatid mite species during year 2018 and 2019.

S. no.	Oribatid mites	Number of samples collected	Percentage (%)
1	*Scheloribates curvialatus* Hammer	253	20.67
2	*Scheloribates* sp.	193	15.77
3	*S. huancayensis* Hammer	125	10.21
4	*Protoribates magnus* Aoki	79	6.45
5	*Rostrozetes foveolatus* Sellnick	97	7.92
6	*Oppia kuehnelti* Kuehnelt	183	14.95
7	*Amerioppia* sp.	29	2.37
8	*Unguizetes clavatus* Aoki	57	4.66
9	*Javacarus kuehnelti* Kuehnelt	123	10.05
10	*Rhysotritia* sp.	27	2.21
11	*Trichoribates* sp.	37	3.02
12	*Galumna* sp.	21	1.72
	Total	1224	

Table 3 : Oribatid mites in different crops at Navsari Agricultural University campus during 2018 and 2019.

S. no.	Species	Year-2018						Year-2019					
		Sugarcane	Rice	Pigeon pea	Lucerne	Castor	Okra	Sugarcane	Rice	Pigeon pea	Lucerne	Castor	Okra
1	*S. curvialatus*	+	+	+	+	+	+	+	+	+	+	+	+
2	*Scheloribates* sp.	+	+	+	+	+	+	+	+	+	+	+	+
3	*S. huancayensis*	-	-	+	+	+	-	-	-	+	+	+	-
4	*P. magnus*	+	+	+	+	+	+	+	+	+	+	+	+
5	*R. foveolatus*	+	+	-	-	-	+	+	+	-	-	-	+
6	*O. kuehnelti*	-	-	-	+	+	-	-	-	+	+	+	-
7	*Amerioppia* sp.	-	-	+	+	+	-	-	-	-	+	+	-
8	*U. clavatus*	-	-	+	+	+	-	-	-	+	+	+	-
9	*J. kuehnelti*	-	-	+	-	-	-	-	-	+	-	-	-
10	*Rhysotritia* sp.	-	-	-	-	-	-	-	-	-	-	-	-
11	*Trichoribates* sp.	-	-	-	-	-	-	-	-	-	-	-	-
12	*Galumna* sp.	-	-	-	-	-	-	-	-	-	-	-	-

Table 4 : Oribatid mites in fruit, timber crops and organic farm at Navsari Agricultural University campus during 2018 and 2019.

S. no.	Species	Year-2018					Year-2019				
		Mango	Coconut	Banana	Teak	Organic farm	Mango	Coconut	Banana	Teak	Organic farm
1	*S. curvialatus*	+	+	-	+	+	+	+	-	+	+
2	*Scheloribates* sp.	-	-	+	-	-	-	-	+	-	-
3	*S. huancayensis*	-	-	+	-	+	-	-	+	-	+
4	*P. magnus*	+	+	+	+	+	+	+	+	+	+
5	*R. foveolatus*	-	-	+	-	-	-	-	+	-	-
6	*O. kuehnelti*	-	-	+	-	-	-	-	+	-	-
7	*Amerioppia* sp.	-	-	+	-	-	-	-	+	-	-
8	*U. clavatus*	+	+	+	+	+	+	+	+	+	+
9	*J. kuehnelti*	-	-	-	-	+	-	-	-	-	+
10	*Rhysotritia* sp.	+	+	+	+	+	+	+	+	+	+
11	*Trichoribates* sp.	+	+	-	+	+	+	+	-	+	+
12	*Galumna* sp.	+	+	+	+	+	+	+	+	+	+

+ = Present, - = Absent.

species in total specimens collected during the survey is summarized in Table 2. Out of all 12 species, the proportion of *Scheloribates curvialatus* Hammer was highest (20.67%) and was followed by *Scheloribates* sp. (15.77%), *Oppia kuehnelti* Kuehnelt (14.95%), *S. huancayensis* Hammer (10.21%) and *Javacarus kuehnelti* Kuehnelt (10.05%). The proportions of specimens of other species were very less as they occurred less frequently during the survey.

The present findings are more or less supported by the work carried out by Acharya and Basu (2014). They recorded 16 species under 13 genera of oribatid mites of Maharashtra state since the extant literature contains the record of only 17 oribatid species belonging to 9 genera and 14 families against 2186 species belonging to 643 genera in 207 families reported from India. Julie (2010) recorded 57 species belonging to 36 genera under 20 families and 14 superfamilies which were representatives of suborder Brachypylina. The present findings are also more or less in accordance with these earlier works.

The oribatid mites were collected from different agro-ecosystems. Among different agro-ecosystems, fruit, timber crops and organic farm supported maximum numbers of species (12 species) as compared to Biodiversity Park (10 species), Pulse and oilseed crops (8 species), Fodder (7 species), Spices and medicinal crops (7 species), Vermicompost bed (6 species), Greenhouse soil (5 species), field crops (4 species) and Vegetable crops (4 species), while fallow land (2 species). Out of 9 species recorded in field, fodder, pulse, oilseed and vegetable crops. In sugarcane, rice and okra recorded same 4 species *viz*., *S. curvialatus, Scheloribates* sp. *P. magnus* and *R. foveolatus*. 8 species *viz*., *S. curvialatus*, *Scheloribates* sp., *S. huancayensis*, *P. magnus*, *O. kuehnelti*, *Amerioppia* sp., *U. clavatus* and *J. kuehnelti* were recorded on pigeon pea, 7 species *viz*., *S. curvialatus, Scheloribates* sp., *S. huancayensis*, *P. magnus*, *O. kuehnelti*, *Amerioppia* sp. and *U. clavatus* were recorded in both castor and lucerne (Table 3). Further, 12 species were recorded from fruit, timber crops and organic farm. In mango, coconut and teak plantation were recorded same six species *viz*., *S. curvialatus*, *P. magnus*, *U. clavatus*, *Rhysotritia* sp., *Trichoribates* sp. and *Galumna* sp., 9 species *viz*., *Scheloribates* sp., *S. huancayensis*, *P. magnus*, *R. foveolatus*, *O. kuehnelti*, *Amerioppia* sp., *U. clavatus*, *Rhysotritia* sp. and *Galumna* sp. were recorded in banana, 8 species *viz*., *S. curvialatus*, *S. huancayensis*, *P. magnus*, *U. clavatus*, *J. kuehnelti*, *Rhysotritia* sp., *Trichoribates* sp. and *Galumna* sp. were found in organic farm (Table 4). A total of 17 species of oribatid mites

Table 5 : Oribatid mites in different locations at Navsari Agricultural University campus during 2018 and 2019.

S. no.	Species	Year-2018						Year-2019					
		Turmeric	Aloe vera	Green-house	Vermicom-post Bed	Biodiversity Park	Fallow land	Turmeric	Aloe vera	Green-house	Vermicom-post Bed	Biodiversity Park	Fallow land
1	*S. curvialatus*	+	+	+	+	+	-	+	+	+	+	+	-
2	*Scheloribates* sp.	-	-	+	+	+	-	-	-	+	+	+	-
3	*S. huancayensis*	+	-	+	+	+	-	+	-	+	+	+	-
4	*P. magnus*	+	+	-	+	+	-	+	+	-	+	+	-
5	*R. foveolatus*	-	-	-	-	+	-	-	-	-	-	+	-
6	*O. kuehnelti*	-	-	+	+	+	-	-	-	+	+	+	-
7	*Amerioppia* sp.	-	-	-	-	+	-	-	-	-	-	+	-
8	*U. clavatus*	+	+	+	+	+	+	+	+	+	+	+	+
9	*J. kuehnelti*	+	-	-	-	-	-	+	-	-	-	-	-
10	*Rhysotritia* sp.	-	+	-	-	+	-	-	+	-	-	+	+
11	*Trichoribates* sp.	-	+	-	-	+	-	-	+	-	-	+	-
12	*Galumna* sp.	-	-	-	-	-	-	-	-	-	-	-	-

Table 6 : Monthly collection of oribatid mites from different agro-ecosystems during 2018.

S. no.	Species	January	February	March	April	May	June	July	August	September	October	November	December
1	*S. curvialatus*	+	+	+	+	+	+	+	+	+	+	+	+
2	*Scheloribates* sp.	-	-	-	-	-	-	-	+	+	+	+	-
3	*S. huancayensis*	+	+	+	+	-	-	+	+	+	+	+	+
4	*P. magnus*	+	-	-	+	-	-	-	+	+	+	+	-
5	*R. foveolatus*	-	-	-	-	-	+	+	+	+	+	+	+
6	*O. kuehnelti*	-	+	+	+	+	+	-	-	+	+	+	-
7	*Amerioppia* sp.	-	+	+	+	+	-	-	-	-	-	+	+
8	*U. clavatus*	-	-	-	-	-	-	-	+	+	+	-	-
9	*J. kuehnelti*	-	+	-	-	-	-	-	+	+	+	-	-
10	*Rhysotritia* sp.	-	-	-	-	-	+	+	+	+	+	+	-
11	*Trichoribates* sp.	-	-	-	-	-	-	+	+	+	+	-	-
12	*Galumna* sp.	-	-	-	-	-	+	+	+	+	-	-	-

+ = Present, - = Absent

Table 7 : Monthly collection of oribatid mites in different agroecosystems at Navsari Agricultural University campus during 2019.

S. no.	Species	January	February	March	April	May	June	July	August	September	October	November	December
1	*S. curvialatus*	+	+	+	+	+	+	+	+	+	+	+	+
2	*Scheloribates* sp.	-	-	-	-	-	-	-	+	+	+	+	-
3	*S. huancayensis*	+	-	-	-	-	-	+	+	+	+	+	+
4	*P. magnus*	+	-	-	-	-	-	-	+	+	+	-	-
5	*R. foveolatus*	-	-	-	-	-	-	+	+	+	+	-	-
6	*O. kuehnelti*	-	-	-	-	-	+	+	+	+	+	+	+
7	*Amerioppia* sp.	-	+	+	+	+	-	-	-	-	-	+	+
8	*U. clavatus*	-	-	-	-	-	-	-	+	+	+	-	-
9	*J. kuehnelti*	-	-	-	-	+	+	-	-	+	+	+	-
10	*Rhysotritia* sp.	-	-	-	-	-	+	+	+	+	+	-	-
11	*Trichoribates* sp.	-	-	-	-	-	-	+	+	+	+	-	-
12	*Galumna* sp.	-	-	-	-	-	+	+	+	+	+	-	-

+ = Present, - = Absent.

Table 8 : Biodiversity indices of Oribatid mites at Navsari Agricultural University campus.

Oribatid species	N	N	n/N=*Pi*	Pi^2	ln *Pi*	*Pi* ln*Pi*
Scheloribates curvialatus	253	1224	0.21	0.0427	-1.5765	-0.32586
Scheloribates sp.	193	1224	0.16	0.0249	-1.8472	-0.29126
S. huancayensis	125	1224	0.10	0.0104	-2.2816	-0.23300
Protoribates magnus	79	1224	0.06	0.0042	-2.7404	-0.17687
Rostrozetes foveolatus	97	1224	0.08	0.0063	-2.5352	-0.20091
Oppia kuehnelti	183	1224	0.15	0.0224	-1.9004	-0.28413
Amerioppia sp.	29	1224	0.02	0.0006	-3.7426	-0.08867
Unguizetes clavatus	57	1224	0.05	0.0022	-3.0668	-0.14282
Javacarus kuehnelti	123	1224	0.10	0.0101	-2.2977	-0.23090
Rhysotritia sp.	27	1224	0.02	0.0005	-3.8140	-0.08413
Trichoribates sp.	37	1224	0.03	0.0009	-3.4990	-0.10577
Galumna sp.	21	1224	0.02	0.0003	-4.0654	-0.06975
			ΣPi^2 =0.1253			$\Sigma Pi \ln Pi$ =-2.23407

n= number of specimens of species. ; N= Total number of specimens of all species. *Pi* = Proportion of S made up of the i^{th} species

belonging to 10 families and 15 genera were identified (nine species were collected from the fields and 17 species were collected from date-palm farms). Among the collected species, *Scheloribates fimbriatus* with 22% relative abundance and *Acrotritia ardua* with 19% were dominant species reported by Ramezani and Mossadegh (2014). In India, Acharya and Basu (2014) recorded 16 species under 13 genera soil oribatid mites in the grape orchards of Nashik and nearby places are more or less similar to the present finding. In spices and medicinal crops total 11 species were recorded, while from greenhouse soil, vermicompost bed, biodiversity Park and fallow land. Moreover, 10 species *viz*., *S. curvialatus*, *Scheloribates* sp., *S. huancayensis*, *P. magnus*, *R. foveolatus*, *O. kuehnelti*, *Amerioppia* sp., *U. clavatus*, *Rhysotritia* sp. and *Trichoribates* sp. were recorded from biodiversity park, which was followed by vermicompost bed (6 species *viz*., *S. curvialatus*, *Scheloribates* sp., *S. huancayensis*, *P. magnus*, *O. kuehnelti* and *U. clavatus*), greenhouse soil (5 species *viz*., *S. curvialatus*, *Scheloribates* sp., *S. huancayensis*, *O. kuehnelti* and *U. clavatus*), turmeric field (5 species *viz*., *S. curvialatus*, *S. huancayensis, P. magnus, U. clavatus* and *J. kuehnelti*), aloe vera (5 species *viz*., *S. curvialatus*, *P. magnus*, *U. clavatus*, *Rhysotritia* sp. and *Trichoribates* sp.), however the fallow land comprised 2 species *viz*., *U. clavatus* and *Rhysotritia* sp. (Table 5). Moreover, maximum numbers of oribatid species were recorded during August-November and moderate population during June-July months in different agro-ecosystems. The monthly variation in population abundance showed that the abundance during August, September or October differed from other of the months with higher abundance and the abundance in May differed from most of the months due to poor abundance reported by Banerjee (2011), thus closely support the present findings as to the higher population abundance of oribatid mites in month of August-November, moderate population in June-July and poor population March-May (Tables 6, 7). *S. curvialatus* was most frequent during the survey and found throughout the survey period on different agroecosystems which followed by *S. huancayensis* and *O. kuehnelti* (Tables 6, 7). Singh and Mukherji (1970) reported *Epilohmannia*, *Peloribates*, *Scheloribates* were dominant genera from Indian soils.

Biodiversity indices : The value of Shannon index of diversity for oribatid mites in different agro-ecosystems at Navsari Agricultural University campus is 2.2340, while the value of Simpson's index of diversity for oribatid mites in different agro-ecosystems is 0.1253 (Table 8). The value of D ranges between 0 to 1, zero represents infinite diversity and 1, no diversity. This value is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give Simpson's index of diversity (1-D). The value of this also ranges between 0 and 1. The value of Simpson's index of diversity for oribatid mites is 0.8747. Moreover, greater is the value, the greater the species diversity. So from this, it can be stated that there is a greater diversity of oribatid mites. The evenness of oribatid mite species in different agro-ecosystems is 0.6650. The species richness of oribatid mites in different agro-ecosystems is 12. The relative abundance is among 12 oribatid species *S. curvialatus* was highest (20.67%) followed by *Scheloribates* sp. (15.77%), *O. kuehnelti* (14.95%), *S. huancayensis* (10.21%) and *J. kuehnelti* (10.05%) as they found most commonly on various crop plants during the survey. Other species occurred very rarely during survey and have low abundance (Table 2).

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