Faunal diversity of mites, especially oribatid mites of mangrove ecosystems of the world in fact represents a very poorly explored area and in India, research works along this line are meager. Kerala being a land blessed with numerous wetland ecosystems supports rich and diverse faunal groups including mites. On a global level, our knowledge on the occurrence, distribution and systematic aspects of oribatid mites inhabiting different terrestrial ecosystems has been enriched by various authorities by supplementing data on the morphology, biology and other ecological parameters of these mites inhabiting in various terrestrial ecosystems at different time intervals. However, difficulties in the recovery of oribatid materials from extremely challenging ecological habitats like the mangrove ecosystems and wetlands, coastal, marine and intertidal systems etc. posed great threat in the progress in the taxonomic and biological studies of these mites and accordingly only very limited information is available in the present scenario. Hence, our knowledge on the faunal diversity and related biological aspects of mangrove dwelling oribatid mites is very much restricted on a global scale and in India, especially in South India practically very little is known on the diversity of these mites in mangrove ecosystems. Considering
the dearth of knowledge on this group of mites in general and that of mangrove ecosystems in particular and duly recognizing the very important roles they play in biodegradation, soil formation, stabilization and nutrient cycling leading to fertility enrichment etc. the present topic was selected for conducting detailed studies. Hence, in the present study an earnest effort was made to present the review in a concise form incorporating almost all available literature on oribatid mites inhabiting mangrove ecosystems of the world. Additionally, the present review also includes the details of earlier scientific explorations on oribatid mites inhabiting habitats like the seashores, islands, wetlands, coastal and intertidal area, salt- marshes etc. distributed throughout the world.

Information on the intertidal species of oribatid mites harbouring the rocky shores and estuaries of the West coast of Ireland was provided by Halbert (1915 & 1920) by conducting extensive surveys. A new genus viz. Fortuynia was erected by Van der Hammen (1960), based on the type species, *F. marina* collected from the intertidal areas of Netherlands, New Guinea. Strenzke (1961) described a new genus, *Selenoribates* with *S. foveiventris* as the type species from the Mediterranean Sea. Schuster (1963) erected a new oribatid mite genus viz. *Thalassozetes* based on the type species, *T. riparius* dwelling in an intertidal habitat at Adriatic Sea Coastal area, Croatia, Bulgaria.
A new genus and species of aquatic oribatid mite viz. *Hydronothrus crispus* was erected by Aoki (1964a) based on the specimens recovered from dead leaves of *Hibiscus tiliaceus* collected from the Island of Kauai, Japan. The same author (1964b) described another new genus viz. *Nesoribatula* with *N.pacifica* as the type species and 4 new species viz. *Scapheremaeus sinuosus*, *Multioppia wilsoni*, *Hypozetes laysanensis* and *Ceratozetes incurvus* from the Layson Island.


Grandjean (1968) erected a new genus *Schusteria* based on type species *S. littorea* from an intertidal habitat. Hammer (1970) reported 8 known and 2 new species of oribatid mites from Easter Islands. The same author (1971) provided the description of 83 species of oribatids from the Fiji Islands, of which 8 genera and 43 species were new to science. She (1972) further described 60 species of oribatids from the Tahiti and Atoll Rangiroa which included 4 new genera, 36 new species and 5 new varieties. Fujikawa
(1972) conducted a survey on the oribatid mite fauna harbouring different vegetations along the Ishikari seashore. The result revealed the presence of 26 species under 25 genera of which, the largest number of individuals was obtained from the vicinity of plant species like *Sasa paniculata* and *Quercus dentata*.

Description of 13 new genera and 57 species of oribatids collected from the Tongatapu and Eua, the Tonga Islands and Upolu was made by Hammer (1973). Data on the distribution and ecology of oribatid mites belonging to the family Ameronothridae harbouring from the terrestrial, limnic and marine habitats of Europe and North America were provided by Schulte *et al.* (1975).

Schuster (1977) enriched our knowledge on the Thalassobiontic oribatid mite family, Selenoribatidae. He further (1979) listed a number of soil mites recovered from the marine environments, especially from the supralittoral as well as in the intertidal area. An extensive survey conducted by Hammer (1979) on the oribatid mites of Java enabled to erect 58 genera and 165 species, of which 10 genera and 103 species were new to science.

Talker *et al.* (1981) studied the oribatid mite fauna of intertidal habitats of the seacoasts of Cebu. They added taxonomic information on the families, Selenoribatidae and Fortuyniidae with the help of SEM images along with description of other acarines.

Søchting and Gjelstrup (1985) reported a number of oribatid mite species from the lichens associated with the rocky seashore’s of North Bornholm. Luxton (1986) added an account on a new species, *F. maculata* collected from the marine littorals of Silver Islands of Kenya. Data on several species of oribatid mites inhabiting the coastal zones of Antarctica were provided by Niedbala (1986) and he also erected a new species, *H. impeditus* from the King George Island. Aoki (1987) described three new species of oribatid mites belonging to a new genus, *Yoronoribates* from the Yoron Island of South Japan. Ito et al. (1987) conducted surveys in different vegetations to explore the oribatid mite fauna of Ishigaki Island, Okinawa, Japan.
Our knowledge on the Indian oribatid mites was enriched by Sanyal and Bhaduri (1988) who reported a total number of 262 species under 132 genera and 57 families distributed over 15 States. Altogether 5 genera, 103 species, 11 subspecies and 1 variety were described as new to science. Pugh (1988) provided a succinct review on the shore-inhabiting Acari of the Isles of Scilly and South-West Peninsula. Piantelli et al. (1990) studied the equilibrium theory of mollusks and oribatid mites of the Aeolian and Tuscan Archipelagos.

Luxton (1990a, b) made a summary on the local distribution pattern of some marine littoral oribatid mites of the New Zealand region. In another paper, the same author (1990c) recorded and enlisted 44 species of oribatid mites from the Isles of Scilly, which contained the illustrations and descriptions of 2 species viz. *Ramusella assimilis* and *Passalozetes bidactylus*, reported for the first time from the British Islands. The same author (1990d) listed 15 species of oribatids from the Holy Island.

Schatz (1991) prepared a catalogue to the known oribatid mites of the Galapagos Islands in the Pacific Ocean. Morell and Subias (1991) listed the oribatid mites collected from many Islands of the archipelago of the Azores of which, 10 were reported as new to science. Luxton (1992) described 4 new genera and 7 new species of oribatid mites from the marine littoral of Hong Kong. A key to the tropical and subtropical littoral oribatid fauna was also
provided. He (1993) erected a new species under the genus *Dometorina* viz. *D. rostrata*, infesting the dead leaves of a mangrove plant, *Avicennia marina* from Hong Kong. A key to the known species of the genus *Dometorina* was also given. Schatz (1994) reported 12 species of Lohmaniid mites from the Islands of Galapagos, Cocos and Central America. Baratti and Bernini (1994) described a new species of Carabodid mite viz. *Odontocephus oglasae* from Montecristo Island of the Tuscan Archipelago. Mahunka (1994) identified a new genus and species of oribatid mite under the family Microzetidae viz. *Comorozetes atavisticus* collected from the soil samples of the Comoro Islands of Africa. The new genus was distinguished by the possession of certain very peculiar characters including 4 pairs of anal setae and shape of the robust setae of palp tarsus.

A new genus viz. *Cordylobates* was erected by Luxton (1995) from the Ascension Island with *C. fragilis* as the type species. Stary (1995) reported 12 species of oribatid mites, including 2 new species viz. *Furcobates levissmithi* and *Oribatella blocki* from Beauchêne, the most isolated Islands Falklands, situated in the South Atlantic Ocean. Norton *et al.* (1996) studied and redescribed the aquatic oribatid mite genus, *Mucronothrus* from California, Oregon and Montana, based on the characters of adults and immatures. Two species were discussed of which, one was new to science. Niedbala and Schatz (1996) reported 37 new species of euptytme oribatid mites of the families Phthiracaridae, Euphthiracaridae, Oribotritiidae and Steganacaridae.
from the Islands of Galapagos, Cocos and Central America. Marshall and Pugh (1996) recorded seven families of oribatid mites from the inland areas of continental Antarctica.

Starý et al. (1997) reported 3449 species of oribatid mites from the sub-Antarctic Heard Island. Yamamoto and Aoki (1997) described a new species, *Malaconothrus iriomotensis* from very wet moss habitats, the foot of Kanpire Waterfall in Irimote Island, Southwest Japan. The new species was very similar to *M. yamamotoi* and *M. kiiensis* and it differed from the known species by having smooth and thin rostral setae, 4 pairs of smooth notogastral setae (*e2, h1, h2 and ps2*), possession of some inner spots on lamellae and area between paired setae *d1* and in the short length of genital and adanal setae. Williams and Williams (1998) collected and reported 20 species of oribatid mites from the fresh water and brackish habitats of Bermuda Islands.

Schatz (1998) made a review on the ecology, faunistics and speciation pattern of oribatid mites inhabiting the Galapagos Islands. While studying the distribution pattern and biogeography of some oribatid mites inhabiting the Islands of Antarctica, sub-Antarctica and nearby land areas, Starý and Block (1998) observed the numerical dominance of members of the families Oppiidae and Ameronothridae. A catalogue to the oribatid mites recovered from the Kashima Islands of Tanabe Bay, Japan was prepared by Yamamoto (1998). Marshall et al. (1999) described 23 species of oribatid mites collected...
from the sub-Antarctic Marion and Prince Edward Islands, of which 2 species belonging to the families Brachychthonidae and Ceratozetidae were new records.

Mercer et al. (2000) reported 6 species of oribatid mites from the rocky shores of Marion Island. A novel species of *Eremaeozetes* viz. *E. sabinae* was described by Schatz (2000) from the Hawaiian Islands. An account on the global distribution pattern of non-halacarid marine-intertidal mites with respect to their origin in marine habitats, including 45 species of oribatid mites belonging to 13 genera and 4 families was provided by Proches and Marshall (2001). The occurrence of the members of the oribatid family Oribatulidae in the mangrove pneumatophores collected from the KwaZulu-Natal, South Africa was reported by Proches et al. (2001). While reviewing the progress made in the hundred years of acarology in the Hawaiian Islands, Swift (2001) and Swift and Goff (2001) reported 43 species of oribatids harbouring different habitats of natural reserves on the Kauai’s Island.

A taxonomic survey carried out on the oribatid mites of the Ogasawara Islands of Japan by Aoki (2002) enabled to describe 2 new species viz. *Diplobodes karubei* and *Xylobates rotundus*. Three new species under the genus *Fortuynia* belonging to the superfamily Ameronothroidea were erected by Marshall and Pugh (2002) from the rocky shores and mangrove litters of Southern Africa. A report on the biodiversity and biogeographical distribution

---

Studies on the Oribatid mites (Acari: Oribatei) Associated with Mangrove Ecosystems of North Kerala
pattern of intertidal acarines of the Southern Africa was made by Proches and Marshall (2002a). The same authors further (2002b) investigated the abundance of acarines in the intertidal mangrove pneumatophores. Niedbala and Niemi (2002) documented the morphological features of some Phthiracaroid mites inhabiting the Pacific Islands, based on Scanning Electron Microscopy. Taxonomic studies carried out by Niedbala (2002) on the ptyctimous mites of the Bermuda Islands yielded 18 species, of which 5 species were new records.

The dominance of oribatid mites in the mudflat baring edges of the mangrove plant, *A. marina* in West Australia was reported by Bartsch (2003). The association of several species of oribatid mites with the mangrove forests of the smaller Okinawa Island of Japan was studied by Karasawa and Hijii (2004a) with respect to their morphological changes. The same authors (2004b) conducted studies on the microhabitat diversity of some oribatid mites inhabiting the mangrove forest of Ryukyu forest in Japan, and observed significant species composition under the barks of knee-root and trunks of *Bruguiera gymnorrhiza*.

Studies by making a preliminary collection of oribatid mites from the Samar Island natural park, Philippines enabled Corpuz-Raros and Gruezo (2005) to report 123 species under 93 genera, 40 families and 4 suborders. Based on washing and direct sampling methods, Karasawa and Hijii (2005)
identified 1,005 individuals representing 23 species of oribatids from the leaves and branches of mangrove plants, from the Okinawa Island, the Ryukyu archipelago of southwest Japan. Moraza and Pena (2005) conducted a faunistic survey of oribatid mites and recorded 150 species representing 56 families, from selected habitats of Canary Islands, Spain. Two new species of Schusteria viz. S. nagisa and S. saxea and one new species of Rhizophobates viz. R. shimojanai were collected and described by Karasawa and Aoki (2005) from the marine littorals of the Ryukyu Archipelago, South Western Japan. The authors transferred 2 African species of the genus Schusteria viz. S. melanomerus and S. ugraseni to the newly described genus.

Niedbala et al. (2006) described 24 species of ptyctimous mites from Samar Islands of the Philippines. Seniczak and Seniczak (2006) provided information on 12 species of oribatid mites collected from mosses, lichens and litter samples of Rhodes Islands of Greece and recorded the abundance of members of genera Pilogalumna, Metabelba and Haplochthonius. Information on the occurrence of 36 species of oribatid mites belonging to 28 genera and 21 families inhabiting the Sundarban delta of West Bengal, India was provided by Sanyal (2006).

Karasawa and Behan (2007) described a new species of oribatid mite belonging to the monotypic genus, Symbioribates, viz. S. aokii collected from the canopy habitats of Ryukyu Islands, Southwestern Japan. The authors
supplemented drawings and SEM photographs of the species along with the descriptions. Majka et al. (2007) presented 4 oribatid families viz. Nothridae, Camisiidae, Ceratozetidae and Hydrozetidae, as new records for the Sable Island of Canada.

Krisper and Schuster (2008) described a new species, *F. atlantica* from the rocky coasts of Bermuda Islands. Scanning Electron microscopy was employed to illustrate the intraspecific variation of the various morphological characters. Karasawa and Hijii (2008) reported 16,325 oribatid mites representing 81 morphospecies from the same habitat with respect to their morphological and life history traits.

While conducting a survey on the oribatid mite species inhabiting 11 different habitats including 4 forest types, 2 bogs, ant hills, decaying wood, moist & dry meadow and seashore in Finland, Pentinnen et al. (2008) reported 165 species of oribatids of which, 17 were new reports from Finland and 52 were confined to the seashore and 12 were distributed in all the habitats mentioned above.

Weigmann (2008) described a new species, *Peloptulus sacculiferus* of the family Phenopelopidae from the coastal habitats of Minho River, of the Lagoon of Aveiro, Southwestern Algarve, Portugal. Further, he redescribed a related species viz. *P. reticulatus* inhabiting at the border of the salt marshes
in the Lagoon of Faro, Southern Portugal and declared *P. trinacriae* as a junior synonym of *P. reticulatus*.

Winchester *et al.* (2008) provided information on 33 species representing 26 genera and 19 families of oribatid mites inhabiting on the canopy of Montane *Abies amabilis* and *Tsuga heterophylla* trees on Vancouver Island of British Columbia. Bayartogtokh *et al.* (2009) conducted a taxonomic study on the marine littoral mites of the family Fortunyiidae collected from Taiwan and India. The authors also described 2 new species viz. *F. taiwanica* and *F. Arabica* along with a key to the world’s known species and subspecies of different genera and data on their distribution. Monson (2009) erected a new species under the genus *Carabodes* viz. *C. scaber* collected from varying habitats of the British Isles.

An investigation on the geographical diversity of oribatid and mesostigmatid mites of Greenland was carried out by Makarova and Böcher (2009) and they listed 109 identified oribatid species. The authors found that 70% of the oribatids were widely distributed (Holarctic and wider), 31% were cosmopolitan or semi cosmopolitan and 5% were conditionally endemic in distribution.

Weigmann (2009a) erected a new halophilous oribatid species, *Punctoribates aveiroensis* from the salt meadows at an upper tidal level in the Lagoon of Aveiro, Portugal. Redescription of 2 species under the known
Studies on the Oribatid mites (Acari: Oribatei) Associated with Mangrove Ecosystems of North Kerala

Review of Literature

21

genus, *Zachvatkinibates* based on the species *Z. quadrivertex* and *Z. eoeryi* recovered from the marine salt-marsh of the same region was also presented by the author. The same author (2009b) erected 2 new species of the families, Scutoverticidae viz. *Scutovertex mikoi* and *Micropirnodus longissimus* a new genus under Scheloribatidae from the coastal habitats of Portugal. He also made a discussion on the new taxonomic position of the genus *Euscheloribates* as a subgenus of *Scheloribates*.

Pfingstl et al. (2009) described 2 new epilittoral species, *S. arenocolus* and *S. pilosetosus* from the sandy shores of the European coasts. Based on morphometric and principal component analysis, these 2 species could be well separated from *S. minutus* and they confirmed distinctly shorter cusps and notogastral setae in *S. arenocolus*.

Bayartogtokh and Chatterjee (2010) proposed a newly revised diagnosis for the genus, *Thalassozetes* and described a new species *T. tenuisetosus* from the marine coastal areas of Western India. In addition to that supplementary description on *Peloribates kaszabi*, *Scheloribates latipes* and *Pergalumna cf. foveolata* was also given. Behan-Pelletier (2010) gave information on the species diversity of oribatid mites in the ecoregions of the Atlantic maritime Ecozone. She recorded 196 species belonging to 118 genera and 58 families. Through a survey on the soil mites inhabiting sand dune habitat of West Coasts of Irelands and Scotland, Arroyo and Bolger (2010)

Aoki and Shimano (2011) surveyed the oribatid mite fauna of Daikoku-Jima Island, Northern Japan and recorded 34 families, 45 genera and 56 species. Bayartogtokh et al. (2011) conducted studies on the diversity and distribution of oribatid mites from the Svalbard Island in the Arctic Ocean. The authors provided redescriptions for 3 known species, *Camisia dictyna*, *Ceratoppia sphaerica* and *Diapterobates notatus* with supplementary descriptions and illustrations. Mahunka (2011) surveyed the oribatid fauna of Madagascar and described 6 new species, Shtanchaeva et al. (2011) collected 36 species of oribatid mites from 17 different habitats of Coastline and Islands of Caspian Ocean and erected a new species *Oribatula (Zygoribatula) caspica* from reed bed meadows.
Corpuz-Raros and Gruèzo (2011) described 5 new species of oribatid mites along with other soil-inhabiting mites collected from Luzon and Mindanao Islands, Philippines. Kagainis and Eitminavičiūtė (2011) reviewed and published the results of 46 years old records of unpublished data of Lithuanian expedition made along the coast of Baltic Sea in the territory of Latvia. The results of the expedition enabled to recover 62 species and 25 morphospecies of oribatid mites, of which 10 were new to science.

Niedbala (2011) described a new species of the genus *Arphthicarus*, viz. *A. andamanensis* from the Andaman Islands. The extensive survey carried out by Wisdom *et al.* (2011) helped to gather information on the occurrence of 43 species belonging to 22 families from the Irish Peat lands. Weigmann (2011) reported, described and redescribed the oribatids of the genera *Xenillus, Oribatella, Galumna, Eupelops* and *Lucoppia* from the salt marsh zones (rocky habitat) of Portugal. Two species viz. *X. halophilus* and *G. paragibbula* were new to science.

Colloff (2012) described 10 new species under the Eremaeozetidae from the Southwestern Pacific region, Australia. He also erected 4 new species under the genus *Rostrozetes* viz. *R. koghisensis, R. mirabilis, R. novaecaledoniae* and *R. fernandezii*, and he presented a key to the genus. A concise review on the oribatid mites transported by birds to the Polar Islands was given by Lebedeva (2012). Schatz and Schuster (2012) recorded and
described 9 species of oribatid mites under the family Lohmanniidae from the Main Island of Bermuda as a first report.

Pfingstl and Schuster (2012a) redefined the family Fortuyniidae based on the adult and juvenile morphology and life history of a new species of littoral mite, *Alismobates inexpectatus* collected from the Atlantic Ocean as the first record. The same authors (2012b) erected a new genus *Carinozetes* with *C. trifoveatus* as the type species from the green algae and pneumatophores of the upper intertidal area of Bermuda Islands. Ermilov et al. (2013) provided a checklist of oribatid mite fauna from riverine environments of six Oceania Islands (Australian region) and made a detailed description of a new species of *Fortuynia* viz. *F. smiti*.

An account on the oribatid mites collected after a tidal wave (Tsunami) from the seashore of Tohoku, Japan, was provided by Nakamura et al. (2013) which comprised of the descriptions of 9 species including 6 new species. Pfingstl (2013a) conducted studies on the diversity of a small family of intertidal oribatid mites viz. Selenoribatidae. He described 3 species viz. *S. quasimodo*, *S.satanicus* and *S.elegans* as new to science from the Archipelago of Bermuda.

Pentinnen and Hämäläinen (2013) conducted studies on the distribution and habitat of a small population of an endemic species, *Austrotritia finlandica* from Finland. Altogether 400 soil samples from
several Islands were investigated, the species was recorded in 16 samples on 13 Islands. Altogether, 64 specimens were collected.

Julie et al. (2013) conducted studies on the diversity of oribatid mites inhabiting mangrove ecosystems of the Calicut district of North Kerala, India and the results of their studies revealed the presence of 17 species belonging to 15 genera and 14 families. Seniczak et al. (2013) investigated the oribatid fauna inhabiting at the edges of bog lakes and pools in Brodnica Lakeland and Orawa- Norvy Targ basin, Poland. Weigmann (2013) provided a detailed systematic list of the oribatid species collected from the coastal areas of Portugal.

Pfingstl et al. (2014) erected a new species under the genus Carinozetes viz. C. mangrovi from the intertidal algae collected from the Islands of Bermuda and Barbados. García-Gómez et al. (2014) conducted studies on the mesoфаunal arthropod diversity of mangrove litter from the Cozumel Island of Mexico and the most abundant species recorded were oribatid mites (61.8%) followed by springtails (14%). Iseki and Karasawa (2014) newly recorded the presence of the genus, Maculobates based on the recovery of the specimens of M. bruneiensis from the mangrove ecosystems of Ryukyu Islands, Japan. Molecular phylogenetic analysis of the specimen was also carried out based on 18S rRNA and the results of which supported the monophyly of Oripodoidea.
While investigating the oribatid fauna of Priazovsky National Wildlife Sanctuary including Kuban Delta, a Ramsar convention wetland, Zaitsev and Pystina (2014) recorded 40 species belonging to 22 families. The authors also established the prevalence of surface – dwelling oribatid mites in sandy coasts and salt marshes in comparison with other oribatid mites from liman – reed beds and rice paddy fields. A new subgenus and 2 new species of Cosmochthonioid mites collected from the olive grove in the South of the Iberian Peninsula were described by Jorrin (2014). Pfingstl (2015a) described 4 new species of intertidal oribatid mites under the genus *Selenoribates* viz. *S. asmodaeus*, *S. arotroventer*, *S. nicus* and *S. divergens* from the coastal regions of Indo- Pacific and Red Sea. He gave information on the morphological diversity in *Selenoribates* based on newly described species. Identification key and global distribution map to all species was also provided. The same author (2015b) described 3 new species, 2 under the genus *Fortuynia* viz. *F. longiseta* and *F. maledivensis* and one species under *Alismobates* viz. *A. pseudoreticulatus* from the littoral environments of Maldives and Singapore. A key to the adult species was also given.