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Global distribution of the thalassobiontic Fortuyniidae and Selenoribatidae (Acari, Oribatida)

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Abstract

The global distribution of Fortuyniidae and Selenoribatidae was updated based on new records and yet unpublished findings. These new data confirm that both families show a transoceanic occurrence on tropical and subtropical coasts. Moreover, it is suggested that the distribution of fortuyniid and selenoribatid mites is correlated with the presence of warm ocean currents and waters. Fortuyniid mites are recorded for the first time from the Archipelago of Hawaii, from Mauritius and the Seychelles. First records of selenoribatid mites include Hawaii, the Canaries and Australia. These records and the discovery of many new species and even a new genus in the Caribbean and the Western Atlantic support the assumption that the biogeographic knowledge about Fortuyniidae and Selenoribatidae is still incomplete and requires further zoogeographical research.

Keywords Biogeography | transoceanic | climate | diversity

1. Introduction

The oribatid mite species of the families of Fortuyniidae and Selenoribatidae represent thalassobiontic organisms and dwell exclusively in the intertidal fringe habitat of subtropical and tropical coasts. The Fortuyniidae consist at present of three genera, *Alismobates* Luxton, 1992, *Circellobates* Luxton, 1992 and *Fortuynia* Hammen, 1960. The genus *Fortuynia* is the most diverse taxon with 12 species, *Alismobates* contains three species and *Circellobates* is monotypic. The Selenoribatidae are represented by seven genera, *Arotrobates* Luxton, 1992, *Carinozetes* Pfingstl & Schuster 2012, *Psednobates* Luxton, 1992, *Rhizophobates* Karasawa & Aoki, 2005, *Schusteria* Grandjean, 1968, *Selenoribates* Strenzke, 1961 and *Thalassozetes* Schuster, 1963. The genus *Selenoribates* consists of six species, *Schusteria* of five species, *Arotrobates*, *Carinozetes* and *Thalassozetes* each of two species and *Psednobates* and *Rhizophobates* are monotypic. Schuster (1966, 1989) provided the first overviews of the geographic occurrences of Fortuyniidae and Selenoribatidae and demonstrated a transoceanic distribution of both families. Procheş and Marshall (2001) recapitulated this information in their paper on global distribution patterns of non-halacarid marine intertidal mites and included some new records of fortuyniid and selenoribatid mites. In the following years, further new species were discovered (Marshall & Pugh 2002, Karasawa & Aoki 2005, Krisper & Schuster 2008, Bayartogtokh et al. 2009, Bayartogtokh & Chatterjee 2010, Pfingstl & Schuster 2012a,b, Ermilov et al. 2013, Pfingstl 2013a,b,c) and the known distribution of these intertidal families changed considerably. Pfingstl and Schuster (2012a) and Pfingstl (2013b) updated distribution patterns of certain taxa but an extensive work summarizing actual biogeographic knowledge of all fortuyniid and selenoribatid mites is still lacking. Therefore this paper gives detailed information about the present global distribution of both intertidal oribatid mite families and provides provisional interpretations of these distribution patterns.

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2. Material and Methods

Presented distribution patterns are based on literature and on unpublished records of material contained in the private collections of Reinhart Schuster and Tobias Pfingstl. The unpublished records are as follows (compare with table 1): **Fortuynia* sp. – Colombia/Cupica Bay, 2 May 1968, R. Schuster; Dominican Republic/Playa Grande, May 1993, R. Schuster; Mauritius/Grand Baie, September 1988, R. Schuster; Singapore/Pulau Ubin, October 2012, leg. I. Bartsch. **Alismobates* sp. – Barbados/Bathsheba Beach, 29 August 2012, T. Pfingstl.

Figure 1. Map showing global distribution of fortuyniid genera.

Figure 2. Global distribution of selenoribatid genera.

*Fortuyniidae gen. sp. – Seychelles/Island La Digue, 8 March 1992, R. Schuster; **Thalassozetes* sp. – France/Île de Porquerolles, August 1959, R. Schuster; *Selenoribatidae gen. sp. – Kenya/Ukunda, July 1989, R. Schuster; Tenerife, 30 March 1989, R. Schuster; Seychelles/Island La Digue, 8 March 1992, R. Schuster; Mauritius/Grand Baie, September 1988, R. Schuster; China/Xiamen – Island Gulangyu, August 1993, coll. R. Schuster; Dominican Republic/Bacardi Island, May 1993, R. Schuster; Australia, Cape Tribulation, August 1992, R. Schuster; Hawaii/Oahu, Big Island, Maui and Kauai, July 1994, R. Schuster.

3. Results

3.1. Distribution of Fortuyniidae

The family of Fortuyniidae shows a transoceanic distribution, whereas most species occur in the Indo-Pacific Ocean (Fig. 1). In the Atlantic Ocean, members of this family are yet restricted to the Caribbean and the Western Atlantic. In the Mediterranean and the Red Sea these mites are not reported up to date. The genus *Fortuynia* is the most diverse and widespread taxon of this group, and representatives can be found on islands in the Western Atlantic and Caribbean region, on African and Asian coasts of the Indo-Pacific, on several islands in the Indo-Pacific region and on Pacific shores of Central America (for details see table 1). *Alismobates*-species were found in the Western Atlantic and the Caribbean, as well as in a limited area in the Indo-Pacific region. The monotypic *Circellobates* is only known from the coast of Hong Kong. There are records of specimens, only determined to the family level, from the archipelago of Galápagos and the Seychelles. Fortuyniid mites are recorded for the first time from the archipelago of Hawaii, from the Seychelles and Mauritius.

3.2. Distribution of Selenoribatidae

The family of Selenoribatidae occurs transoceanically on tropical and subtropical shores of all oceans. Species of this group are present throughout the Indo-Pacific Ocean, in the Atlantic their distribution is mainly confined to Western Atlantic areas and a few species occur in the Mediterranean and the Red Sea (Fig. 2). The genus *Schusteria* is the most widespread taxon of this family with occurrences on South American Atlantic coasts, on African and Asian Indo-Pacific shores and in Eastern Pacific regions (Tab. 1). *Thalassozetes*-species are reported from the Western Mediterranean, the Adriatic and the Black Sea, a few locations in the Indo-Pacific Ocean, and there is a first record of the genus in the Atlantic Ocean from the island of Barbados. Half of all *Selenoribates* species are distributed in the Mediterranean and the Red Sea and the other half occurs on the small archipelago of Bermuda in the Western Atlantic. A further undetermined *Selenoribates* species was recently found in Singapore in the Indo-Pacific area. The genus *Carinozetes* is presently restricted to the Caribbean region and parts of the Western Atlantic. The genera *Arotrobates*, *Psednobates* and *Rhizophobates* were found in a very small area in the Indo-Pacific Ocean, namely in Hong Kong and Japan. Selenoribatid mites are recorded for the first time from the Archipelago of Hawaii, the Canaries and Australia.

4. Discussion

Several authors (e.g. Schuster 1989, Procheş & Marshall 2001) already reported a tropical and subtropical distribution of fortuyniid and selenoribatid mites and recent records of specimens of these two families confirm this assumption. The record of *F. elamellata* on the temperate New Zealand (Luxton 1967) seems at first sight to be an exception, but this species was found on the North Island which shows rather subtropical temperatures and hence is referred to as ‘the winterless North’ by locals. The record of an undetermined selenoribatid species from the coast of Long Island New York (reference to the record in the USA, Schuster 1989), on the other hand, represents an unusual case as New York shows a typical temperate climate with seasonally strongly varying air and ocean temperatures. However, the warm Gulf Stream flows northwards near the coast of New York and thus may explain this record. Schuster (1966) already assumed that the occurrence of fortuyniid and selenoribatid taxa is correlated with warm ocean currents and the present distribution patterns support this hypothesis. For example, there are numerous records of selenoribatid mites from the Atlantic coast of South America, where the warm Brazil Current flows southwards, but the Pacific shore of South America, with its cold northwards flowing Humboldt Current, is completely devoid of these mites. A similar situation is given at the southern tip of the African continent; the warm Agulhas Current flows along the Indo-Pacific coast and fortuyniid and selenoribatid mites can settle there, whereas at the same latitudes on the Atlantic shore the cold Benguela Current is present and mites are absent in this region. In general, there is not a single record

Table 1. Detailed list of worldwide records of fortuyniid and selenoribatid taxa.

Taxon	Ocean	Country/Region	Authors
Fortuyniidae			
Fortuynia atlantica	WA	Bermuda	21, 24
F. arabica	IWP	India	22
F. elamellata	IWP	New Zealand, Japan, South Africa	7, 10, 18
F. inhambanensis	IWP	Mozambique	18
F. maculata	IWP	Kenya	13
F. marina	IWP	Indonesia	1
F. rotunda	IWP	Mozambique, Japan	18, 20
F. sinensis	IWP	Hong Kong	15
F. smiti	IWP	New Caledonia	28
F. taiwanica	IWP	Taiwan	22
F. yunkeri	EP	Panama	4
Fortuynia sp.	WA, IWP, EP	Barbados, Costa Rica, Mexico, Mauritius*, Maldives, New Caledonia, Dominican Republic*, Pakistan, Philippines, Singapore*, Colombia*	12, 14, 26, UR
Alismobates inexpectatus	WA	Bermuda	24
A. reticulatus	IWP	Hong Kong, Japan	15, 19, 20
A. rotundus	IWP	Hong Kong	15
Alismobates sp.	WA(CS)	Costa Rica, Barbados*	26, UR
Circellobates venustus	IWP	Hong Kong	15
Fortuyniidae gen. sp.	EP, IWP	Galapagos, Seychelles*	16, UR
Selenoribatidae			
Arotrobates granulatus	IWP	Hong Kong, Japan	15, 19, 20
A. lanceolatus	IWP	Hong Kong	15
Carinozetes bermudensis	WA	Bermuda	25
C. trifoveatus	WA	Bermuda	25
Carinozetes sp.	WA(CS)	Barbados, Jamaica	26
Psednobates uncunguis	IWP	Hong Kong	15
Rhizophobates shimojanai	IWP	Japan	20
Schusteria littorea	WA, EP	Brazil, Galapagos	8, 16
S. melanomerus	IWP	Mozambique	17
S. nagisa	IWP	Japan	20
S. saxea	IWP	Japan	20
S. ugraseni	IWP	South Africa	17
Schusteria sp.	EP, WA	El Salvador, Brazil	8
Selenoribates elegans	WA	Bermuda	27
S. foveiventris	IWP(RS)	Egypt	2
S. ghardaqensis	IWP(RS)	Egypt	9
S. mediterraneus	MS	Croatia, France, Greece	5, 6
S. quasimodo	WA	Bermuda	27
S. satanicus	WA	Bermuda	27
Selenoribates sp.	IWP	Singapore	27
Thalassozetes riparius	MS	Croatia, Bulgaria	3, 11
T. tenuisetosus	IWP	India	23
T. barbara	WA	Barbados	29
Thalassozetes sp.	IWP, WA(CS), MS	Philippines, France*	12, UR
Selenoribatidae gen. sp.	EA, WA, EP, IWP	Costa Rica, St. Lucia, Dominica, Kenya*, New York, Brazil, Cap Verde, Tenerife*, Seychelles*, Mauritius*, China*, Maldives, Dominican Republic*, Australia*, Hawaii*, Ecuador	11, 14, UR

Codes for the oceanographic region: **EA**/Eastern Atlantic, **WA**/Western Atlantic, **MS**/Mediterranean Sea including Adriatic and Black Sea, **IWP**/Indo-West Pacific, **EP**/Eastern Pacific, **(CS)**/Caribbean Sea, (**RS)**/Red Sea. *refers to yet unpublished records.

Numbers referring to authors: **1** – Van der Hammen (1960), **2** – Strenzke (1961), **3** – Schuster (1963), **4** – Van der Hammen (1963), **5** – Grandjean (1966), **6** – Schuster (1966), **7** – Luxton (1967), **8** – Grandjean (1968), **9** – Abd-El-Hamid (1973), **10** – Aoki (1974), **11** – Schuster (1977), **12** – Talker et al. (1981), **13** – Luxton (1986), **14** – Schuster (1989), **15** – Luxton (1992), **16** – Schatz (1998), **17** – Marshall & Pugh (2000), **18** – Marshall & Pugh (2002), **19** – Karasawa & Hijii (2004), **20** – Karasawa & Aoki (2005), **21** – Krisper & Schuster (2008), **22** – Bayartogtokh et al. (2009), **23** – Bayartogtokh & Chatterjee (2010), **24** – Pfingstl & Schuster (2012a), **25** – Pfingstl & Schuster (2012b), **26** – Pfingstl (2013a), **27** – Pfingstl (2013b), **28** – Ermilov et al. (2013), **29** – Pfingstl (2013c) **UR** – unpublished records.

of fortuyniid or selenoribatid mites from coasts with prevailing cold ocean currents, thus the distribution of Fortuyniidae and Selenoribatidae is obviously influenced by aquatic temperature conditions as well as by the regional climates.

The distribution areas of fortuyniid and selenoribatid mites show congruency in most regions of the world and their transoceanic occurrence suggests an evolutionary old age of both families. However, in the Atlantic Ocean the Selenoribatidae are much wider distributed than the Fortuyniidae and the presence of selenoribatid genera in the Mediterranean and the Red Sea points probably to a past distribution of ancestral taxa on coasts of the Tethys Sea. On the other hand, the limited occurrence of Fortuyniidae in the Western Atlantic, may indicate that this family was absent in the Tethys Sea and invaded the Atlantic via the formerly open seaway between the North and South American continent in geologically recent times, shortly before the closure of the Central American isthmus.

Although the records of fortuyniid and selenoribatid mites are comprehensive, allowing provisional interpretations of the biogeographic data, still large gaps in the distribution patterns can be assumed which remain to be filled or explained. The recent first records of new fortuyniid and selenoribatid species and a new genus within the Caribbean and parts of the Western Atlantic (Pfingstl & Schuster 2012a,b; Pfingstl 2013b, c), as well as several other first records, demonstrate that our knowledge on the distribution of these mites is still incomplete and that the diversity of these two families may be higher than formerly supposed.

Recently, a new species, *Fortuynia smiti* was found far inland in a river in New Caledonia (Ermilov et al. 2013) and based on the morphological description there is no doubt that this species belongs to the genus *Fortuynia*. However, as all other fortuyniid species represent exclusively thalassobiont organisms, this record is absolutely unusual from an ecological point of view! Unfortunately the authors did not recognize the abnormality of this finding and neither gave detailed information about sampling circumstances explaining the freshwater occurrence nor discussed this ecological exception in a single word. Cases of thalassobiont mites invading freshwater habitats are very rare, for example, Schuster (1986) demonstrated that the marine associated species *Ameronothrus maculatus*, member of the family Ameronothridae, is able to colonize riverbanks many kilometres upstream under typical freshwater conditions and thus shows an exceptional ecological range. The same could apply to *F. smiti* and therefore the further investigation of this unusual fresh water record would be very important.

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