First record of intertidal oribatid mites (Acari, Oribatida) from the Canaries – a new species and its complete ontogeny.

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Abstract

A new species of intertidal oribatid mites from Tenerife is described and its full ontogenetic development is given in detail. *Thalassozetes canariensis* **sp. nov.** can easily be distinguished from its congeners by its characteristic notogastral cuticular pattern showing loosely distributed irregular elevations, and its rectangular median sternal cavity. Based on morphology, *Thalassozetes canariensis* **sp. nov.** is most closely related to the Mediterranean *T. riparius*; both species share a small transversal band-like notogastral light spot and the longitudinal orientation of lyrifissure *iad*. The juvenile morphology of *T. canariensis* **sp. nov.** conforms basically to those of known *Thalassozetes* juveniles but there are discrepancies in certain aspects that require further research into all known species. This report of *T. canariensis* **sp. nov.** from Tenerife is the first record for the Canaries, and also for the Eastern Atlantic area. Further records of this species within the area may be expected.

Keywords: Selenoribatidae, *Thalassozetes*, littoral, Atlantic, development

Introduction

The genus *Thalassozetes* belongs to the Selenoribatidae, a family of oribatid mites that are completely adapted to an intertidal lifestyle. They basically feed on intertidal algae and tolerate daily tidal inundation by using elaborate plastron respiration (e.g. Pfingstl 2017). Members of this family are distributed on subtropical and tropical coasts all around the globe (Pfingstl & Schuster 2014). Subías (2004, update 2020) lists a total of seven known *Thalassozetes* species in his catalogue but nearly half of these were transferred to this genus without justification or explanation. They thus constitute erroneous classifications as outlined in detail in Pfingstl and

Schuster (2012) or in Pfingstl (2013). In fact, there are only four *Thalassozetes* species known worldwide. These are *Thalassozetes riparius* Schuster, 1963, *T. tenuisetosus* Bayartogtokh & Chatterjee, 2010, *T. barbara* Pfingstl, 2013 and *T. balboa* Pfingstl, Lienhard & Baumann, 2019. The type species *T. riparius* was initially found on the Croatian Adriatic coast (Schuster 1963) and remains the only species present in the Mediterranean Sea so far (Pfingstl & Schuster 2014). *Thalassozetes tenuisetosus* was recorded on the coast of India (Bayartogtokh & Chatterjee 2010) and although Talker *et al.* (1981) reported the occurrence of an undetermined *Thalassozetes* species from the Philippines, these specimens were recently described as members of the selenoribatid genus *Indopacifica* (Resch *et al.* 2019). Therefore *T. tenuisetosus* is the only representative of this genus known from the Indo-Pacific area. *Thalassozetes barbara* and *T. balboa* were both found in the Caribbean region (Pfingstl 2013, Pfingstl *et al.* 2019), whereas *T. barbara* is confined to the Western Caribbean (Pfingstl *et al.* 2016) and *T. balboa* to the Eastern Caribbean (Pfingstl *et al.* 2019).

Although the complete morphological ontogeny of *Thalassozetes* is unknown, data on juvenile morphology have been provided for at least two of the species. Schuster (1963) gave a brief description of the larva, proto- and tritonymph of *T. riparius* and Bayartogtokh and Chatterjee (2010) presented data on the deuto- and tritonymph of *T. tenuisetosus*.

Recently, adult and juvenile specimens of a yet undescribed *Thalassozetes* species were found on Tenerife, one of the seven main Canary Islands, located in the Atlantic Ocean close to the northwest African coast. This archipelago is of volcanic origin, with maximum geological ages ranging from 21 to 1 million years (Ma). With an approximate age of 12-3.5 Ma, Tenerife is at an intermediate evolutionary stage relative to the other western and eastern islands (Ancochea *et al.* 1990, Troll & Carracedo 2016). In general, they have a Mediterranean climate; with warm temperatures and a dry summer (del Arco Aguilar & Rodríguez, 2018). However, they show a large number of micro-climates. These are mainly due to their relief and varying elevation, which govern their topographical exposure to the humid trade winds associated with the cool Canary Current (del Arco Aguilar & Rodríguez, 2018). The record of *Thalassozetes* is the first for the Canaries and the Eastern Atlantic.

The aim of the present manuscript is to provide a detailed description of this new species, as well as comprehensive data on its ontogenetic development, and to update biogeographic information on the genus *Thalassozetes*.

Material and Methods

Sampling and location

Intertidal red algae (*Gelidium pusillum*), growing in the upper eulittoral zone, were scraped off the rocks with a knife during low tide. Freshly collected samples were examined under a stereomicroscope (Leica ES2). Mites were manually separated with dissecting needles, storing specimens directly in pure ethanol.

Locality: La Barranquera, La Laguna, Tenerife, Canary Islands, Spain; this is a rocky shore area, with high hydrodynamism, especially in autumn and winter (Fig. 1); coordinates 28.538111°, -16.396722°; sampling date 7 Sep. 2019; collected by Juan Carlos de la Paz.

Drawings

Preserved animals were embedded in Berlese mountant for microscopic investigation in transmitted light. Drawings were made with an Olympus BH-2 microscope equipped with a drawing attachment. These drawings were first scanned, then processed and digitized with the free open-source vector graphics editor Inkscape (<https://inkscape.org>). Morphological terminology used in this paper follows that of Grandjean (1953, 1968) and Norton & Behan-Pelletier (2009).

Descriptions

Family Selenoribatidae Schuster, 1963

Genus *Thalassozetes* Schuster, 1963

***Thalassozetes canariensis* sp. nov.**

Diagnosis

Slender gastronotic region; a pair of short parallel ridges on anterior gastronotic region; loosely distributed irregular cuticular elevations covering notogaster; 14 pairs of gastronotic setae; median rectangular deepening on epimeron I; three pairs of adanal setae; proximoventral tooth present on claws.

Description of adult

Measurements. Females (n = 6), length: 313–338 µm (mean 327 µm), width: 203–206 µm (mean 204 µm); males (n = 5), length: 313–325 µm (mean 317 µm), width: 175–197 µm (mean 186 µm). Integument. Colour brown. Cerotegument finely granular, larger granules on pedotecta and acetabular regions. Cuticle of notogaster with large irregular elevations.

Prodorsum (Figs 2A, 3A). Rostrum rounded in dorsal view and demarcated from remainder of prodorsum by faint transverse ridge. Rostral (*ro*) and lamellar setae (*le*) simple and short. One pair of conspicuous slightly converging lamellar ridges reach from bothridium to insertion of

lamellar seta. Interlamellar seta (*in*) very short and blunt, an oblique faint ridge posterior to this seta. Exobothridial seta (*ex*) minute. Bothridium large cup with irregular edges. Sensillus clavate and short, distal head densely spinose.

Gnathosoma. Palp setal formula 0-2-1-3-9 (including solenidion). Solenidion ω on tarsus not associated with eupathidium *acm*. Chelicera chelate, with two teeth on each digit. Setae *cha* and *chb* of approx. same length, both dorsally slightly pectinate. Distal part of rutellum developed as thin triangular membrane slightly curved inward, with longitudinal incision. Setae *a* and *m* long, smooth. Mentum regular, finely granular, seta *h* simple, long.

Notogastral region (Figs 2A, 3A). Notogaster slender and oval in dorsal view. Dorsosejugal suture complete but weakly developed medially. A pair of small rounded humeral projections oppose bothridia. Transversal band like narrow median light spot on anterior border of notogaster. A pair of short longitudinal ridges on anterior gastronomic region; obvious cuticular depressions between and lateral to ridges. Irregular cuticular elevations loosely distributed over notogaster, medially and posteriorly circular, laterally longitudinal; in some specimens the longitudinal elevations seem to form two long parallel lines crossing the notogaster from the notogastral ridges to the posterior region. Fourteen pairs of thin, setiform notogastral setae (8-16 μ m), *c*₁, *c*₂, *da*, *dm*, *dp*, *la*, *lm*, *lp*, *h*₁₋₃, *p*₁₋₃; but *c*₃ absent. Five pairs of lyrifissures, *ia* oblique adjacent to humeral projection, *im* between setae *c*₂ and *la*, *ih* next to seta *lp*; *ips* anterior to seta *p*₃ and *ip* between setae *p*₂ and *p*₁. Orifice of opisthonotal gland *gla* posterior and close to lyrifissure *im*.

Lateral view (Figs 2C, 3C). Pedotectum I *PtI* present, round, small; pedotectum II absent. Groove-like depression along lateral sejugal furrow anteriorly demarcated by faint ridge. Lateral enantiophysis consisting of two opposite projections, *S*₁ round and *S*₂ slightly pointed. Discidium *di* as prominent triangular bulge.

Podosoma and venter (Figs 2B, 3B). Faint rectangular median deepening on epimeron I. Epimeral setation 1-0-1-1, seta *lb* long, reaching trochanter III, setae *3b* and *4a* short and thin. Three pairs of short, fine genital setae arranged in longitudinal row. Insertion of tendon β next to anterior corners of genital orifice. Aggenital seta absent. Obvious longitudinal ridge adjacent to acetabulum IV. Two pairs of short anal setae *an*₁₋₂. Preanal organ triangular in ventral view, interior anchor-shaped. Three pairs of short setiform adanal setae *ad*₁₋₂, first two pairs lateral and third pair posterior to anal opening. Lyrifissure *iad* longitudinal, flanking anterior border of anal orifice.

Legs (Fig. 4). Monodactylous. Long hook-like claws with one small proximoventral tooth. Femora with slightly projecting ventral carina. No porose areas detectable. Famulus ε on tarsus I short, broad, conical knob. Setation and solenidia (Table 1).

Type material

La Barranquera, La Laguna, Tenerife, Canary Islands, Spain. 7 September 2019. Holotype (female) and two paratypes (male and female) deposited in the zoological collection of the Department of Animal Biology, Edaphology and Geology at the University of La Laguna (DZUL). Four additional paratypes from the same locality (two males and two females) deposited in the collection of the Senckenberg Museum für Naturkunde Görlitz (SMNG).

Etymology

The specific epithet ‘canariensis’ refers to the Canary archipelago of which Tenerife is part.

Common features of juvenile stages

Apheredermous. Colour brown. Integument plicate and soft, except for centrodorsal plate. Centrodorsal plate showing small irregularly distributed circular elevations. Prodorsum triangular, anterior finely granular, rostrum rounded, lamellar ridges well developed. Rostral (*ro*) and lamellar seta (*le*) normal, interlamellar seta (*in*) and exobothridial seta (*ex*) minute, the latter on small apophysis. Sensillus clavate, distally spinose. Bothridium cup-like, laterally opened. Gnathosoma no obvious difference from adult stage. Cerotegument ventrally finely granular, larger granules in acetabular regions and ventral furrows. Ventral furrows typical of selenoribatid juveniles. In nymphal stages no distinct genital sclerites, genital opening thin longitudinal slit. Legs monodactylous.

Larva.

Length (N=3) 157–194 μm (mean 179 μm).

Gastronotic region (Fig. 5A). Eleven pairs of notogastral setae; *c*₁₋₃, *da*, *dm*, *dp*, *la*, *lm*, *lp*, *h*₁₋₂; *h*₃ absent; centrodorsal setae thick, robust and barbed in this stage, others simple and setiform. Weak transverse ridge on centrodorsal plate, passing posterior line of setae *dm* and *lm*.

Ventral region of idiosoma. Epimeral setation 1-0-1, epimeral seta *1a* conspicuously longer than *3a*. Claparède’s organ *cla* globular.

Legs. Setation and solenidia (Table 1).

Protonymph

Length (N=7): 200–243 μm (mean 230 μm).

Gastronotic region (Figs 5B, 6B). Fifteen pairs of setiform notogastral setae; c_{1-3} , da , dm , dp , la , lm , lp , h_{1-3} and p_{1-3} , all approximately same length and shape.

Ventral region of idiosoma (Fig. 6A). Epimeral setation 1-0-1-1. Seta $4a$ medially on trochanter IV. One pair of short genital setae. Aggenital setae absent.

Legs (Fig. 7). Setation and solenidia (Table 1).

Deutonymph

Length (N=8): 246–289 μm (mean 272 μm).

Gastronotic region (Fig. 5C). Fifteen pairs of notogastral setae, same positions and shapes as in protonymph.

Ventral region of idiosoma (Fig. 6C). Epimeral setation 1-0-1-1. Two pairs of short genital setae arranged in a longitudinal row. Three pairs of adanal setae ad_{1-3} flanking anal valves, two pairs of vestigial anal seta already present in this stage.

Legs. Setation and solenidia (Table 1).

Tritonymph

Length (N=5): 313–344 μm (mean 322 μm).

Gastronotic region (Figs 5D and 8A, C). Fifteen pairs of notogastral setae, no difference from deutonymph.

Idiosoma ventral region (Figs 6D and 8B). Epimeral setation 1-0-1-1, no difference from deutonymph.

Three pairs of short genital setae in longitudinal row. Three pairs of adanal setae ad_{1-3} , same as in deutonymph. Two pairs of short anal setae an_{1-2} .

Legs. Setation and solenidia (Table 1).

Remarks

The new taxon can easily be distinguished from all other known species by its characteristic notogastral cuticular pattern, showing loosely distributed irregular elevations. The Mediterranean *T. riparius* shows a reticulate pattern, both Caribbean species *T. barbara* and *T. balboa* reticulate-foveate and the Indian *T. tenuisetosus* strongly granular (Table 2). Another character facilitating determination is the rectangular median sternal cavity in *T. canariensis* **sp. nov.**, whereas *T. tenuisetosus* lacks such a cavity completely. In *T. riparius* it is circular and in both Caribbean species it is shaped like an inverted pear (Table 2).

Discussion

Comparing the morphological characters of the five *Thalassozetes* species (see Table 2), three biogeographical groups become evident, showing their own apomorphies. (I) The Mediterranean – Eastern Atlantic group with *T. riparius* and *T. canariensis* **sp. nov.** are characterized by a small transversal band-like notogastral light spot and their adanal lyrifissure *iad* orientated longitudinally framing the anal opening. (II) The Caribbean grouping of *T. barbara* and *T. balboa* share a specific reticulate-foveate cuticular notogastral pattern and their sternal epimeral cavity is shaped like an inverted pear. (III) The still monotypic Indo-Pacific group with *T. tenuisetosus* lacks the notogastral light spot, notogastral ridges, and epimeral cavity, and shows an exceptional epimeral setation and a normally developed famulus on tarsus I. Accordingly, their phylogenetic relationships seem to strongly correlate with geographical occurrence. However, for a clear assessment more species records from the Indo-Pacific area would be necessary as well as concomitant molecular genetic analyses.

The juvenile morphology of *T. canariensis* **sp. nov.** basically conforms to those of known *Thalassozetes* juveniles, which means they show the same typical plication with a centrodorsal plate. They all show faint prodorsal lamellar ridges and broadened centrodorsal setae in the larva (Schuster 1963, Bayartogtokh & Chatterjee 2010). Moreover, the developmental patterns are as in most other selenoribatid juveniles, i.e. notogastral setation 11-15-15-15 (larva to tritonymph), epimeral setation 1-0-1 (larva) and 1-0-1-1 (all nymphs), and genital setation 0-1-2-3 (larva to tritonymph) (Grandjean 1966, 1968; Pfingstl & Schuster 2012). However, juveniles of *T. riparius* and *T. tenuisetosus* show obvious deviations in this respect. For example, the protonymph of *T. riparius* has only 13 notogastral setae and already one pair of adanal setae that usually appears first in the deutonymph (Schuster 1963). It is possible that the pair of adanal seta was in fact one of the notogastral setae (p- series) that are located close to the anal orifice in the protonymph. This mistake could be explained by the early appearance of a pair of adanal seta and the accompanying lack of notogastral setae. The deutonymph of *T. tenuisetosus* shows only 10 pairs of notogastral setae, already three pairs of genital and 3 pairs of adanal, whereas the tritonymph shows 14 notogastral and only two pairs of anal setae (Bayartogtokh & Chatterjee 2010). Moreover, the epimeral setae of epimeron III and IV are absent in both stages and only develop in the adult (Bayartogtokh & Chatterjee 2010). All these divergences are very unusual, especially the loss of one pair of adanal setae from deuto- to tritonymph that then reappears in the adult stage. Juveniles are very small and identifying all their setae is rather difficult, therefore mistakes may happen but more ontogenetic observations

of *Thalassozetes* are necessary to either dismiss or confirm these unusual variances in development.

This description of *T. canariensis* **sp. nov.** from Tenerife is the first record of any *Thalassozetes* for this geographical region. Pfingstl and Schuster (2014) already reported the occurrence of a selenoribatid species from the same island, but this was based on the personal observation of one author and the respective specimens were never further determined. Therefore, it is impossible to say whether this report was based on *T. canariensis* **sp. nov.** or if it referred to a different species. However, it is very likely that *T. canariensis* **sp. nov.** also occurs on other islands of the Canaries and that further selenoribatid species will be found distributed over this archipelago.

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Figure captions

FIGURE 1. Photographs of the type locality La Barranquera, Tenerife. A. Overview, showing large intertidal rocks. B. Detail showing barnacles and red algae growing in and near crevices.

FIGURE 2. *Thalassozetes canariensis* **sp. nov.** adult male. A. Dorsal view; legs omitted. B. Ventral view; distal leg segments and mouthparts omitted. C. Lateral view, legs drawn without setation.

FIGURE 3. *Thalassozetes canariensis* **sp. nov.** adult female, stacked stereomicroscopic images. A. Dorsal view. B. Ventral view. C. Lateral view.

FIGURE 4. *Thalassozetes canariensis* **sp. nov.** adult left legs, antiaxial view. A. Leg I. B. Leg II. C. Leg III. D. Leg IV. Scale bar applies to all four legs.

FIGURE 5. *Thalassozetes canariensis* **sp. nov.** juvenile stages in dorsal view; legs omitted. A. Larva. B. Protonymph. C. Deutonymph. D. Tritonymph.

FIGURE 6. *Thalassozetes canariensis* **sp. nov.** juvenile stages ventrolateral views. A. Protonymph ventral view. B. Protonymph lateral view. C. Deutonymph ventral view. D. Tritonymph ventral view. Distal legs segments omitted in ventral views and legs drawn without setation in lateral view.

FIGURE 7. *Thalassozetes canariensis* **sp. nov.** protonymph left legs, antiaxial view. A. Leg I. B. Leg II. C. Leg III. D. Leg IV. Scale bar applies to all four legs.

FIGURE 8. *Thalassozetes canariensis* **sp. nov.** stacked stereomicroscopic images of deutonymph. A. Dorsal view. B. Ventral view. C. Lateral view.

TABLE 1. Development of leg setation in *Thalassozetes canariensis* **sp. nov.** from larva to adult. First appearance denoted by letters. () = pairs of setae, - = no change with regard to preceding stage.

	Instars	Trochanter	Femur	Genu	Tibia	Tarsus	Chaetome	Solenidia
Leg I	larva	-	$d, (l)$	$(l), \sigma$	$(l), v', \varphi_1$	$(pl), (pv), s, (a), (u), (p), (tc), (ft), \varepsilon, \omega_1$	0-3-2-3-16	1-1-1
	protonymph	-	-	-	-	ω_2	0-3-2-3-16	1-1-2
	deutonymph	-	-	-	φ_2	-	0-3-2-3-16	1-2-2
	tritonymph	-	-	-	-	(it)	0-3-2-3-18	1-2-2
	adult	-	-	-	-	-	0-3-2-3-18	1-2-2
Leg II	larva	-	$d, (l)$	$(l), \sigma$	l', v', φ	$(pv), s, (a), (u), (p), (tc), (ft), \omega$	0-3-2-2-13	1-1-1
	protonymph	-	-	-	-	-	0-3-2-2-13	1-1-1
	deutonymph	-	-	-	-	-	0-3-2-2-13	1-1-1
	tritonymph	-	-	-	l''	(it)	0-3-2-3-15	1-1-1
	adult	-	-	-	-	-	0-3-2-3-15	1-1-1
Leg III	larva	-	d, l'	l', σ	l', φ	$(pv), s, (a), (u), (p), (tc), (ft)$	0-2-1-1-13	1-1-0
	protonymph	-	-	-	-	-	0-2-1-1-13	1-1-0
	deutonymph	-	-	-	-	-	0-2-1-1-13	1-1-0
	tritonymph	-	-	-	-	-	0-2-1-1-13	1-1-0
	adult	v'	-	-	v''	-	1-2-1-2-13	1-1-0
Leg IV	protonymph	-	-	-	-	$(pv), (u), (p), ft''$	0-0-0-0-7	0-0-0
	deutonymph	-	d, l'	l'	l', v', φ	$s, (a), (tc)$	0-2-1-2-12	0-1-0
	tritonymph	-	-	-	-	-	0-2-1-2-12	0-1-0
	adult	v'	-	-	v''	-	1-2-1-3-12	0-1-0

TABLE 2. Comparison of important morphological characteristics of all known *Thalassozetes* species.

character	<i>T. riparius</i>	<i>T. canariensis</i> sp. nov.	<i>T. tenuisetosus</i>	<i>T. barbara</i>	<i>T. balboa</i>
body length (µm)	298-318	313-338	334-346	274-286	277-312
seta <i>in</i>	short	short	normal	short	short
seta <i>ex</i>	minute	minute	vestigial	minute	minute
notogastral cuticle	reticulate	irregular elevations	granular	reticulate-foveate	reticulate-foveate
light spot	small band	small band	absent	large rectangular	large triangular
notogastral ridges	3 pairs	1 pair	absent	1 pair	1 pair
notogastral setae	13 (c ₃ , h ₁ absent)	14 (c ₃ absent)	14 (p ₁ absent)	14 (c ₃ absent)	14 (c ₃ absent)
epimeral setation	1-0-1-1	1-0-1-1	1-0-1-2	1-0-1-1	1-0-1-1
epimeral cavity	circular	rectangular	absent	inverted pear-shape	inverted pear-shape
genital setae	3	3	3	3	3
adanal setae	3	3	3	3	2
anal setae	2	2	2	2	2
lyrifissure <i>iad</i>	longitudinal	longitudinal	transversal	transversal	transversal
tarsal famulus	short knob-like	short knob-like	normal	short knob-like	short knob-like
teeth on claws	1	1	1	1	2