

A new species of *Typhlocharis* Dieck, 1869 (Coleoptera: Carabidae: Anillini) from South Spain, with notes on the phylogenetic value of sexually related characters and the presence of stridulatory organ (*pars stridens*) in the genus

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Abstract

A new species of the genus *Typhlocharis* Dieck, 1869 (Coleoptera: Carabidae: Anillini) is described (*T. deferreri* **nov. sp.**) from the province of Cadiz in the south of the Iberian Peninsula. Its affinities with other species are discussed, mainly those with males having a median tubercle in sternum II: *T. bivari* Serrano and Aguiar, 2006, *T. passosi* Serrano and Aguiar, 2005, *T. navarica* Zaballos and Wrase, 1998 (*outereloi* group), *T. monastica* Zaballos and Wrase, 1998 and *T. peregrina* Zaballos and Wrase, 1998 (*monastica* group). The value of sexual dimorphism as a phylogenetic and taxonomic tool is revised; seemingly there is no relationship between this kind of sexual dimorphism and the traits that differentiate the established species groups (umbilicate series, type of gonocoxite, dimorphism in tibiae I and II, etc.). The presence and significance of stridulatory organ (*pars stridens*) is also commented upon, updating and increasing the scarce data available about this structure, poorly considered in the literature, with notes about distribution and relationships of the species which have it.

Key words: Carabidae, Anillini, Typhlocharina, *Typhlocharis*, South Spain, Cadiz, sexual dimorphism, *pars stridens*

Resumen

Se describe una nueva especie del género *Typhlocharis* Dieck, 1869 (Coleoptera: Carabidae: Anillini) (*T. deferreri* **nov. sp.**) de la provincia de Cádiz en el sur de la península Ibérica. Se establecen sus afinidades con otras especies, principalmente aquellas en las que los machos presentan un tubérculo medial en el esterno II: *T. bivari* Serrano y Aguiar, 2006, *T. passosi* Serrano y Aguiar, 2005, *T. navarica* Zaballos & Wrase, 1998 (grupo *outereloi*), *T. monastica* Zaballos y Wrase, 1998 y *T. peregrina* Zaballos y Wrase, 1998 (grupo *monastica*). Se revisa el valor de este tipo de dimorfismo sexual como herramienta filogenética y taxonómica; no pareciendo existir relación entre este tipo de dimorfismo y los caracteres que diferencian los grupos de especies establecidos (serie umbilicada, tipo de gonocoxitos, dimorfismo en tibias I y II, etc.). También se comenta la presencia e importancia de *pars stridens*, actualizando y ampliando los escasos datos disponibles sobre esta estructura poco considerada en la literatura, con notas sobre la distribución y relaciones de las especies que la presentan.

Palabras clave: Carabidae, Anillini, Typhlocharina, *Typhlocharis*, sur de España, Cádiz, dimorfismo sexual, *pars stridens*

Introduction

The genus *Typhlocharis* currently includes 50 species (Andújar *et al.* 2010) of very small endogean carabid beetles (from the 0.9 mm of *Typhlocharis quadridentata* Coiffait, 1969 to the 2.9 mm of *Typhlocharis carinata* Serrano and Aguiar, 2006). Most of these species have been described during the last 20 years (Zaballos and Pérez-González 2010). The special traits of this genus (Jeannel 1937) gave Dieck (1869) the impression that they should be included in Cucujidae, probably related with *Laemophloeus* Dejean, 1835 (today a member of its own family,

Laemophloeidae, Cucujoidea), and Marseul (1873) maintained this opinion. Later, Abeille (1874) and Ehlers (1883) included *Typhlocharis* within the tribe Anillini (Carabidae), currently composed by the subtribes Typhlocharina (monogeneric), Anillina and Scotodipnina (Zaballos 2003).

When Dieck (1869) described with exquisite detail *Typhlocharis silvanoides*, the first species of this genus, he noted that it shared the same habitat (under deeply buried stones in clay-sandy soils in Tanger, Morocco) with *Anillus massinissa* Dieck, 1869 [nowadays *Geocharis massinisa* (Dieck, 1869)] pointing out that usually *Typhlocharis* preferred the underside of the stone, whereas *Geocharis* preferred the soil. After 25 years of collecting Anillini in the Iberian Peninsula and northern Morocco, we can confirm that they frequently live together in the same habitats and in some instances we have found one or more species of *Typhlocharis* (Zaballos & Banda 2001) living in syntopy with not more than one of *Geocharis*.

After several attempts sampling *Geocharis korbi* Ganglbauer, 1900 during a winter field campaign in 1997, we found one specimen of *Typhlocharis* in a site north of Chiclana (Cadiz, Spain). New sampling efforts in February 1998 resulted in the capture of three *Geocharis* specimens (see Zaballos 2005) and numerous *Typhlocharis* specimens under different stones. All of these *Typhlocharis* specimens belong to a new species and the aim of this work is to present its description and affinities with the closest relatives, representing the fifty-first member of the genus. The taxonomic and phylogenetic significance of a stridulatory organ at the back of the head (named *pars stridens* onwards) is also commented upon.

Material and methods

The material studied was collected during two field campaigns in the Province of Cadiz, Andalusia, Spain, in 1997 and 1998.

All the specimens of the new species were collected by hand directly with a thin (under number 000) white-haired paint brush from under deeply buried stones and preserved in Scheerpeltz liquid.

The morphological studies were done with light microscopy. The specimens were mounted and preserved on cards using D.M.H.F. resin (Bameul 1990), some of them in cards with glass window to allow microscopical study.

Measurements and drawings were done with a Zeiss 474620–9900 microscope, and software Adobe Photoshop CS2 9.0.

The nomenclature of setae follows Zaballos (2005).

The typical series are deposited in Coll. Zaballos, Universidad Complutense de Madrid (UCM) and in the Museo Nacional de Ciencias Naturales (MNCN), Madrid and other particular collections (see type series below).

To establish the affinities of the new species and update the data used in the discussion, a study was made of specimens preserved in the collections of: Museum national d'Histoire naturelle, Paris (*T. silvanoides* Dieck, 1869, *T. armata* Coiffait, 1969, *T. santschii* Normand, 1915, *T. quadridentata* Coiffait, 1969, *T. algarvensis* Coiffait, 1971), Museum für Naturkunde, Berlín (*T. silvanoides*, *T. santschii*), Deutsches Entomologisches Institut, München (*T. silvanoides*), Museo Nacional de Ciencias Naturales, Madrid (*T. silvanoides*, *T. santschii*) and Coll. J.P. Zaballos (32 species, mainly type material). Data from other species has been obtained from the literature.

Results

Typhlocharis deferreri Zaballos & Pérez González new species

(Figs. 1–3)

Type series. Holotype: 1 ♂ (n° 10), 27-01-1998, Cortijo La Mesa–La Nava. Chiclana. Cádiz, 33 m (N 36° 24' W 6° 03'), J.P.Zaballos leg. Paratypes: 1 ♂, 9-02-1997, same locality, J.P.Zaballos leg; 34 ♂♂, 34 ♀♀, 27-01-1998, same locality, J.P.Zaballos leg. Holotype in Coll. Zaballos UCM, Paratypes in coll. Pérez-González (4 ex.), coll. Wrase (4 ex.), coll. Ruíz-Tapiador (4 ex.) and MNCN, Madrid (4 ex.) (ref. number 2107), rest of Paratypes in Zaballos UCM (52 ex.),

Diagnosis. Anophthalmous, small endogean beetle with yellow-brownish microreticulate integument with scattered pubescence. Body parallel and depressed. Elytra without teeth in the posterior margin, and 4+3 setae in

the umbilicate series (fig. 1). Legs I and III with a marked internal angle in the femora. Sexually dimorphic. Abdominal sternum II of males with a median tubercle, absent in females which have deep foveae instead (fig. 2). Genitalia as in figure 3.

Description. Length of Holotype: 1.35 mm. Length of paratypes: 1.16–1.41 mm (males), 1.17–1.48 mm (females). Head wider (0.25–0.3 mm in males, 0.24–0.32 mm in females) than long (0.2–0.21 mm in males, 0.18–0.21 mm in females), with irregular microsculpture, except in front, clypeus and labrum. *Pars stridens* present in the posterior region of the head (horizontal ridges near the vertex region). Labrum with a triangle-shaped area and a little bump of thicker cuticle. Mouth parts and antennae without apparent special features. Cephalic chaetotaxy (fig. 1): labrum with three pairs of setae and two minute pairs of setae associated; clypeus with two pairs of setae, those on the side much longer; frontal region with one pair close to the frontal sulcus, two pairs of supraocular setae (anterior and posterior), one supra-antennal pair and one genal pair; two pairs of temporal setae and sparse pubescence.

Pronotum slightly longer (0.31–0.41 mm in males, 0.3–0.42 mm in females) than wide (0.3–0.36 mm in males, 0.3–0.4 mm in females), subquadrate, posterior angles with 2–3 minor rounded denticles. Surface covered with subhexagonal to irregular microsculpture. There is one medial sulcus and one pair of lateral sulci. Chaetotaxy (fig. 1): one pair of setae in the anterior quarter of the pronotum, one pair in the posterior angles, five or six pairs in the anterior margin, and two pairs in the posterior margin. Pubescence in four or five rows on the disc. Margins with a row of pubescence, a little denser in the anterior and posterior margins.

Elytra approximately twice as long (0.65–0.80 mm in males, 0.68–0.85 mm in females) as wide (0.31–0.37 mm in males, 0.31–0.42 mm in females), sides parallel, apex rounded. Lateral margins serrate, with 19–22 small teeth, decreasing in size posteriorly. Apical margin without teeth, but with the sutural angle slightly asymmetric. Surface covered with subhexagonal to irregular microsculpture. Scutellar organ present near the base of the suture. Disc flattened and with lateral carinae in the seventh stria. Chaetotaxy: umbilicate series with four setae in the anterior group and three in the posterior group (4+3). The distribution of the setae of the anterior group is characteristic: the third seta is separated by twice the distance between setae 1° and 2° and the 4° seta is separated twice the distance between 2° and 3° (fig. 1). Pubescence in five rows, lateral margins with one small seta in each denticle and apical margin with a row of small setae. There are two scutellary setae, but no discal or apical long setae.

Legs similar in both sexes. Profemora and metafemora robust, the inner margin with a marked internal angle. The metatrochanters are rounded. There are no mesotibial hairs in males.

Abdomen covered by irregular and large sized microsculpture, except the last segment which has a “belt” of scaly and serrate microsculpture (fig. 2). Females with a deep foveae in the sternum II and very slightly foveae in sternum III and IV. Males typically lack this foveae (if present, it is extremely superficial), but have a small, pointed median tubercle in the sternum II, with two small setae near the basis. Chaetotaxy of the last segment shows sexual dimorphism (fig. 2).

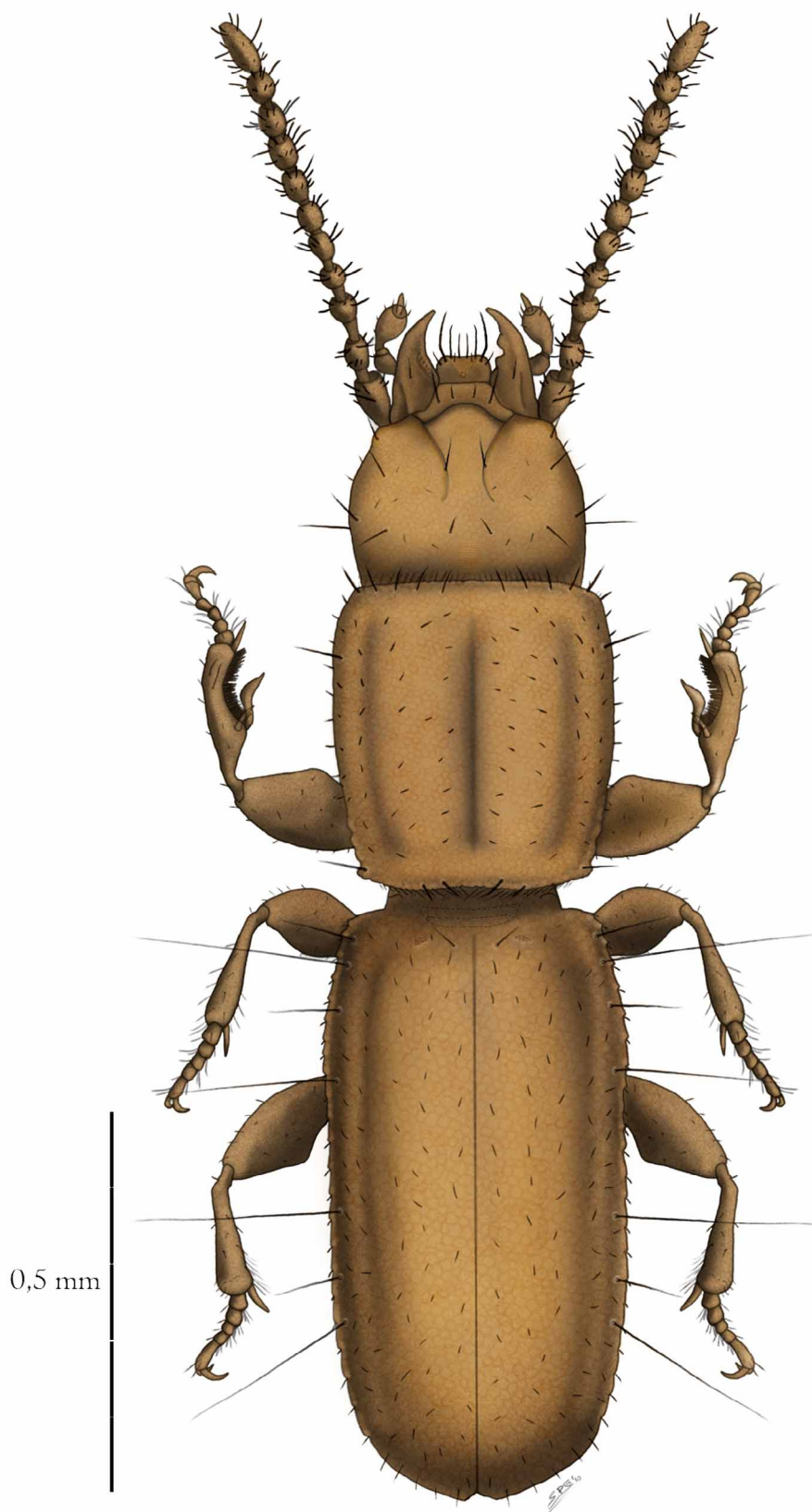
Aedeagus (fig. 3a) with sickle-shaped median lobe, short and robust (0.22 mm), arcuate, with a screw-shaped sclerite in the internal sac. In dorsal view the apex is bent to the left. Both parameres are subtriangular with two short setae in the apex.

Female genitalia (fig. 3b) with long, tubular gonocoxites, with two fused apical setae in each one and scarce sensillae with some degree of individual variation. The gonoduct is short and shows the same thickness along its length, except at the connection with the spermatheca, which is funnel-shaped. The spermatheca is peanut-shaped in lateral view and subspherical in dorsal view. The spermathecal gland is cone-shaped.

Habitat. The majority of the type specimens were captured on a stormy day during January 1998 under deeply buried stones in open land with mainly clay soils (with little sand content), wet, but not saturated. The vegetation was mainly represented by fan palms (*Chamaerops humilis* L.), mastic trees (*Pistacia lentiscus* L.) and white asphodel (*Asphodelus albus* Miller). In this habitat also lives another Anillini, *Geocharis korbi* Ganglbauer, 1900 (Zaballos 2005).

Etymology. The new species is named *in memoriam* of Juan de Ferrer Andreu, great entomologist, great friend, a truly great man.

Affinities. This new species can be assigned to the *diecki* group (*sensu* Zaballos and Ruíz-Tapiador 1997), because it shows the umbilicate series pattern (4+3); a group that currently includes a further 9 species (Andújar *et al.* 2008). *Typhlocharis deferreri* **nov. sp.** can be separated from all the other species of the group by having secondary sexual dimorphism on the ventral sternites: males have a median tubercle in the posterior margin of sternum II and females have quite deep posterolateral foveae in sternum II (fig. 2).



T. deferreri

FIGURE 1. Habitus ♂ of *Typhlocharis deferreri* nov. sp.

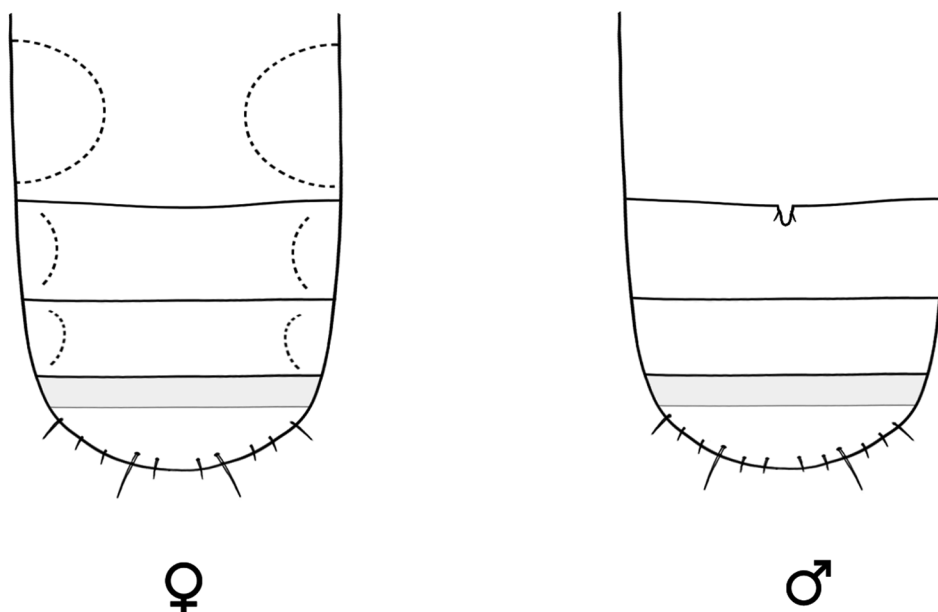


FIGURE 2. Abdomen (ventral view) of female and male, showing the median tubercle, the foveae, the chaetotaxy of the last segment and the “belt” of scaly microsculpture (shaded in grey).

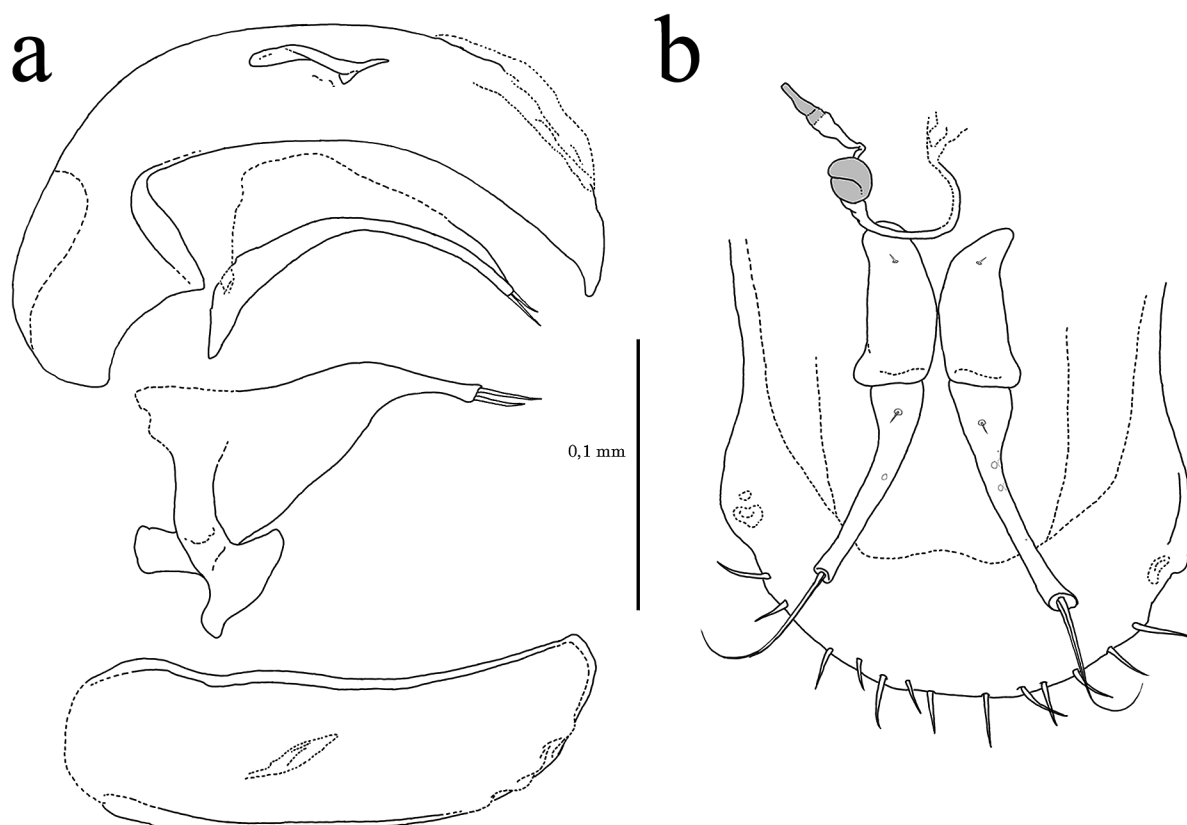


FIGURE 3. Aedeagus in lateral and dorsal view, parameres in lateral view (a). Female genitalia in ventral view (b).

This combination of traits (sexual dimorphism with presence of a median tubercle in males and 4+3 umbilicate series) is present also in other species of the genus that are included in different species groups: *T. bivari* Serrano and Aguiar, 2006 and *T. passosi* Serrano and Aguiar, 2005 (*gomezi* group) differ by the presence of a median tooth on clypeus, two teeth in tibiae II and III of males and two teeth in the posterior margin of elytra (absent in the new species). On the other hand, *T. navarica* Zaballos and Wrase, 1998 (*outereloi* group), *T. monastica* Zaballos and

Wrase, 1998 and *T. peregrina* Zaballos and Wrase, 1998 (*monastica* group) have a median tubercle in males, but they have 4+2 umbilicate series and teeth in the posterior margin of elytra (4+3 and unarmed in the new species).

The angle of the inner margin of the profemora relates *T. deferreri* with *T. armata*, *T. silvanoides* and *T. algarvensis*; which are geographically close. However, *T. deferreri* is different from any of these by the combination of traits already commented, specially the sexual dimorphism.

The genitalia characters also support a close relationship of *T. deferreri*, *T. armata* and *T. silvanoides*. These species share similar shape of gonocoxites, spermatheca and spermathecal gland, but in *T. deferreri* **nov. sp.** the gonoduct is a tube with regular thickness, while in the other two species the gonoduct has two well differentiated regions of different thickness. The aedeagus is very similar too, being shorter and more robust in the new species. Finally it is interesting to note that the distribution pattern of the anterior group of setae from the umbilicate series (fig. 1) is very similar to that of *T. carmenae* Zaballos and Ruíz-Tapiador 1995 and *T. martini* Andújar *et al.* 2008, both from the *diecki* group.

Discussion

According to Jeannel (1937), the particular habitus of "all" the *Typhlocharis* species include the following diagnostic features: parallel elytra, seventh stria of elytra forming a carina, almost quadrangular pronotum, very short legs, umbilicate series without a posterior pair, etc. These features confused Dieck (1869), misidentifying *Typhlocharis* as Cucujidae; and today they justify the entity of the monogeneric subtribe Typhlocharina in the tribe Anillini, distinct from the subtribes Anillina and Scotodipnina. It is postulated that as currently treated, *Typhlocharis* is a monophyletic taxon that became diversified in several lineages still undefined phylogenetically.

The new species shares certain traits with other species that are supposed to be not closely related, which suggests a reinterpretation of the species groups as currently known. Traditionally, there have been some key morphological traits used to classify the different species into several well defined species groups (Zaballos & Ruíz-Tapiador 1997), but recent research gives some evidence that these are not natural groups and do not reflect the true phylogenetic relationships of the genus (Andújar *et al.* 2010, Zaballos & Pérez-González 2010). However, those groups are still useful to identify and work with taxa of this large genus.

With the increase of the knowledge on the genus *Typhlocharis* (51 species including *T. deferreri* **nov. sp.**) new questions about their evolutionary history arise. The last described species were still included in the morphological groups established by Zaballos and Ruíz-Tapiador (1997), but recent studies (Andújar *et al.* 2010, Zaballos and Pérez-González 2010) suggest that these are not natural groups. As shown in Zaballos and Pérez-González (2010), only the *baetica* (6 species), *gomezi* (6 species) and *carpetana* (2 species) groups keep a biogeographic and taxonomic coherence, while the other 37 species should be reassigned using different criteria, as compared to those used by Zaballos and Ruíz-Tapiador (1997).

The new species adds more evidence to this criticism, given that its most diagnostic trait, the median tubercle of males, also appears in species of other groups (*gomezi*, *monastica* and *outereloi*) (Zaballos and Wrase 1998; Serrano *et al.* 2005; Serrano and Aguiar 2006a) which otherwise are significantly different. However, apart from this dimorphism and the pattern of umbilicate series, *T. deferreri* **nov. sp.** is extremely similar in its morphology to *T. armata* and *T. silvanoides*, both of them geographically close and respectively belonging to *diecki* and *silvanoides* groups (but share median body size, lack of discal setae, posterior margin of elytra without teeth, shape of femora, shape of male and female genitalia, etc.).

It seems that there are no relationship between this kind of sexual dimorphism and the traits used to differentiate the species groups (umbilicate series, type of gonocoxite, dimorphism in tibiae I and II, etc.). The fact that the median tubercle is found in geographically distant species (Montes Vascos, Ribatejo in Portugal and Cadiz) suggests two hypotheses: a common origin of that structure and a diversification of the species with regards to other traits, or a case of convergence between different lineages, thus rendering the median tubercle as an homoplasy relatively easy to develop.

Another structure not yet considered to establish taxonomic relationships in the genus is the *pars stridens*. It is used to produce sounds and usually consists of rows of parallel ridges in a body part which can be moved against another one with a hard edge (*plectrum*). The repeated movement creates a sound and it is not rare within Arthropoda, as sound producing structures of this kind have been described in several groups such as spiders, crabs, assassin bugs, butterflies, ants and other beetles (e.g. Jocqué 2005, Boon *et al.* 2009, Yinon *et al.* 1971, Barbero *et al.* 2009, Wessel 2006).

This stridulatory organ is known in 30 species of *Typhlocharis* (Table 1). The other 21 species lack this trait. It is always located in the medial area of the vertex region (fig. 4). The movement of the head against the anterior margin of the pronotum may produce a sound of a certain frequency not yet known.

TABLE 1. Species of *Typhlocharis* with *pars stridens* and its distribution in the different known species groups (*sensu* Zaballos & Ruíz-Tapiador 1997).

<i>monastica</i> group	<i>gomezi</i> group	<i>carpetana</i> group	<i>silvanoides</i> group	<i>baetica</i> group	<i>diecki</i> group	<i>outereoi</i> group
<i>T.monastica</i>	<i>T.wrasei</i>		<i>T.silvanoides</i>	<i>T.baetica</i>	<i>T.santschii</i>	<i>T.outereoi</i>
<i>T.toletana</i>	<i>T.passosi</i>		<i>T.armata</i>	<i>T.pacensis</i>	<i>T.besucheti</i>	<i>T.laurentii</i>
	<i>T.fozcoaensis</i>		<i>T.algarvensis</i>	<i>T.aguirrei</i>	<i>T.lunai</i>	<i>T.bazi</i>
	<i>T.bivari</i>		<i>T.fancelloi</i>	<i>T.millenaria</i>	<i>T.rochapitei</i>	<i>T.singularis</i>
			<i>T.sarria</i>	<i>T.furnayulensis</i>	<i>T.martini</i>	<i>T.gomesalvesi</i>
			<i>T.carinata</i>	<i>T.matiasi</i>	<i>T.deferreri</i>	
			<i>T.paulinoi</i>			

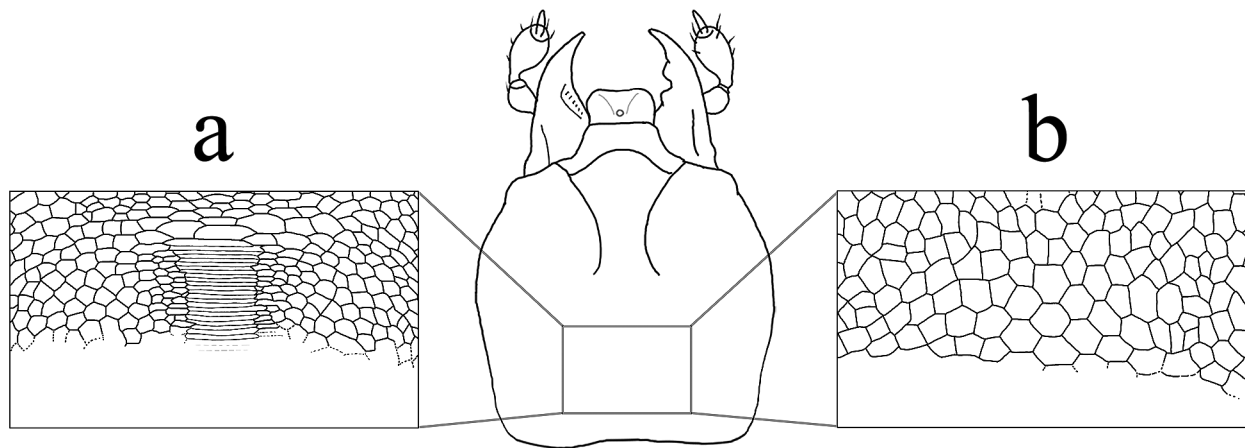


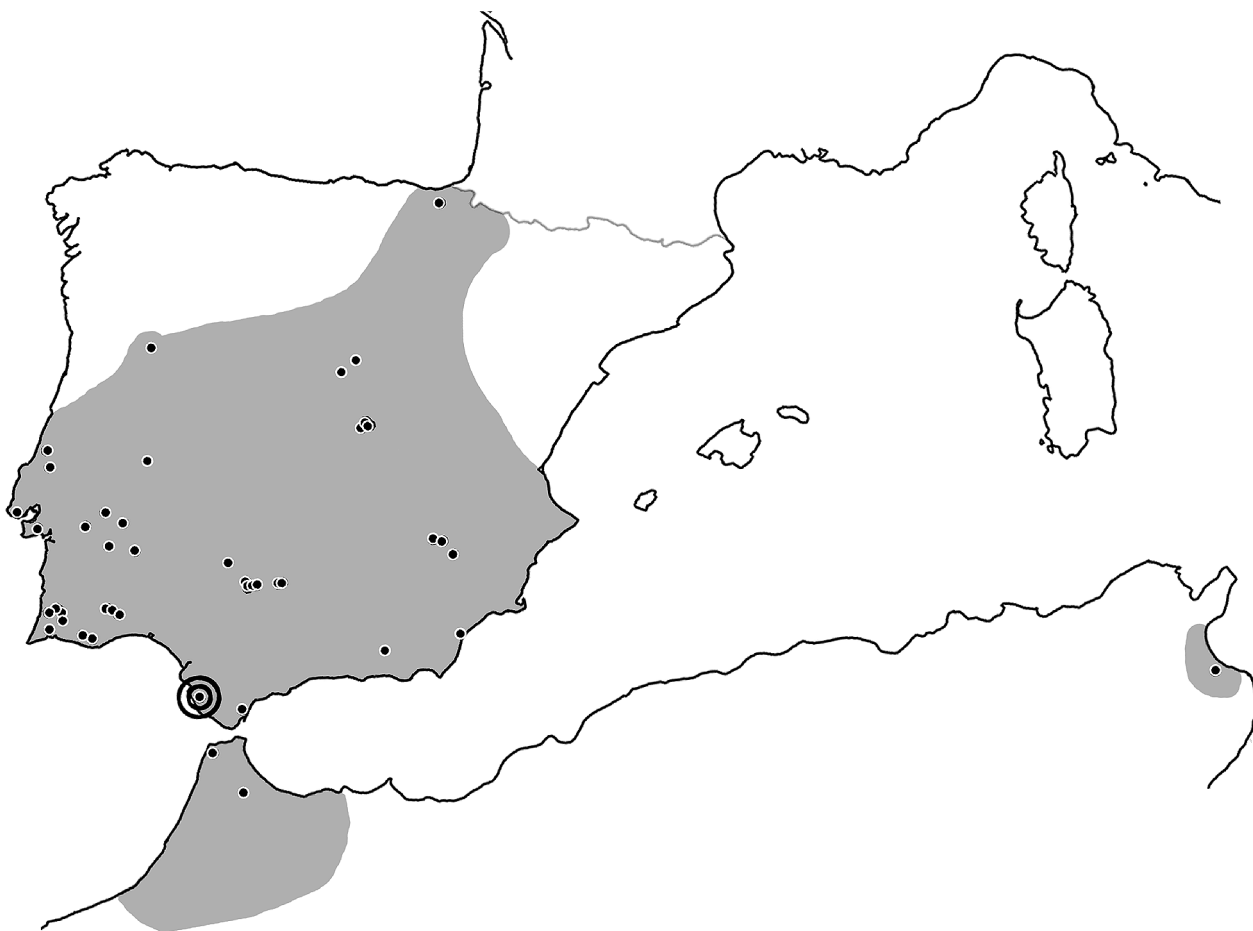
FIGURE 4. Pattern of microreticulation in the vertex region of *T. monastica* (a) and *T. farinosae* (b) showing the differences between species with and without *pars stridens*. (Modified from Zaballos & Wrase 1998, Zaballos & Ruíz-Tapiador 1997).

In the dark and silent edaphic world, the production of sound can be very useful for communication. Assuming the monophyletic origin of *Typhlocharis*, it seems logical to think that the presence of *pars stridens* would be advantageous and maybe part of the original body plan of the *Typhlocharis* genus. The presence of the *pars stridens* in species groups with 4+4 and 4+3 umbilicate series (Table 1), which are supposed to be closer to ancestral Anillini (Jeanne 1973), and the widespread occurrence of the *pars stridens* within the genus may be indicative of this structure as a plesiomorphic trait, secondarily lost in some lineages.

Nevertheless, not all the *Typhlocharis* species have this organ. If it is supposedly advantageous in the endogean environment, why not all species of *Typhlocharis* (or even other endogean carabids) are known to have it? There are some possibilities explaining this fact: 1) lack of use or some behavioral change that make the original function irrelevant, 2) replacement by other communication systems (pheromones, etc.), 3) these species never had stridulatory organ and it appeared several times independently within the genus (case of multiple convergence), 4) sound emission related with conspecific competence for resources (food, space, mating, etc.).

Given that almost all the other known Anillini are endogean, it is very probable that the ancestors of *Typhlocharis* were endogean too. This and the fact that other Anillini seem to lack this kind of stridulatory organ (Zaballos and Pérez-González *pers. obs.*) would favour an evolutionary scenario with the acquisition of *pars stridens* as an apomorphy acquired by endogean ancestors of *Typhlocharis*. A possible alternative but less parsimonious, is to consider non-stridulating *Typhlocharis* ancestors and the acquisition of the stridulatory organ by parallel evolution in several lineages of this genus.

In the map showing the species that have this trait (map 1), it is observed that the majority of them are spread across the southwestern part of the Iberian Peninsula and North Africa. Only *T. santschii* (Tunis) and *T. monastica* (Navarra) are quite far from this “noisy-core”, and *T. fozcoaensis*, *T. bazi*, *T. outerelei* and *T. toletana* are present at the center of the Iberian Peninsula.



MAP 1. Distribution map of genus *Typhlocharis* (grey area): black dots mark the location of the species known with *pars stridens*. Concentric circles mark the location of *T. deferreri* **nov. sp.**

Most species with stridulatory organ have a 4+4 or a 4+3 umbilicate series formula. All the species of the *silvanoides* and *baetica* groups and many of the *diecki*, *monastica* and *gomezi* groups have *pars stridens*, whereas it is sporadically present among the members of the *outerelei* group and absent in the *carpetana* group. If the hypothesis of the ancestral nature of the *pars stridens* is correct, then it is concluded that the number of setae from the umbilicate series is a much more variable character than the presence of *pars stridens*. This kind of plasticity in characters traditionally considered quite stable for taxonomic relationships is specially observed in the *baetica* group (Zaballos and Banda 2001).

In spite of the absence of a phylogenetic hypothesis for the genus, this study suggests that the secondary sexual characters are probably more homoplastic rather than apomorphic, and that the *pars stridens* is likely plesiomorphic for the genus. This hypothesis leads to likewise consider the umbilicate series as a homoplastic character.

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