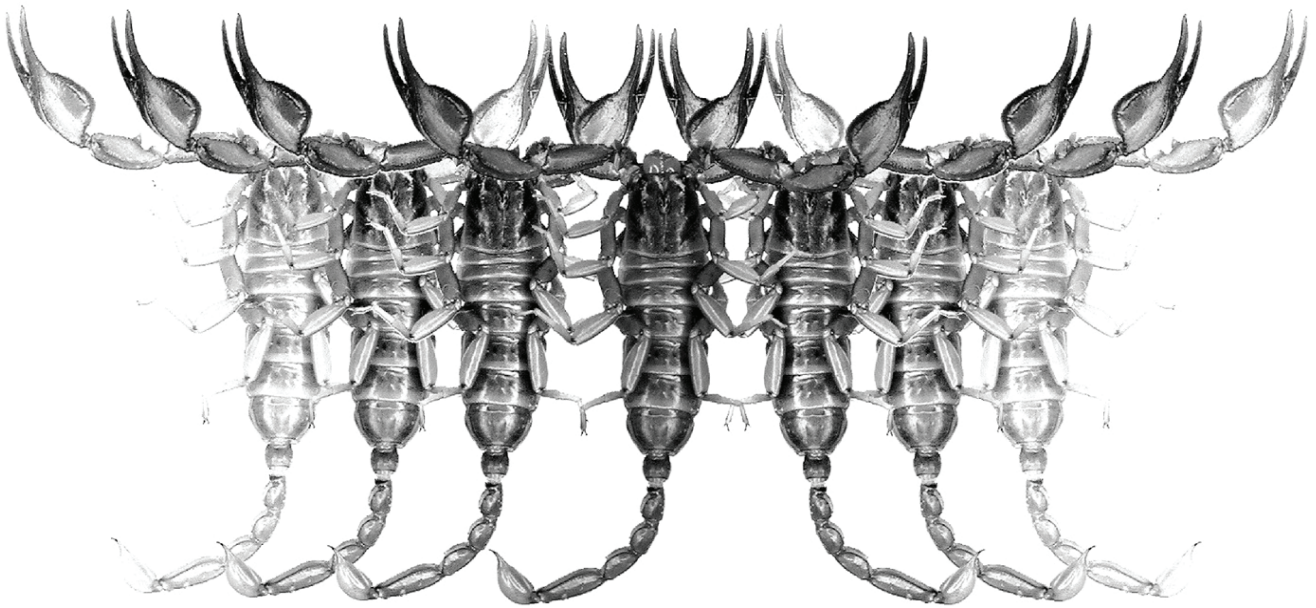


Euscorpius

Occasional Publications in Scorpiology



**Seven new Alpine species of the genus
Alpiscorpius Gantenbein et al., 1999, stat. n.
(Scorpiones: Euscorpiidae)**

František Kovařík, Jana Štundlová, Victor Fet & František Štáhlavský

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Occasional Publications in Scorpiology

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Derivatio Nominis

The name *Euscorpius* Thorell, 1876 refers to the most common genus of scorpions in the Mediterranean region and southern Europe (family Euscorpidae).

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Seven new Alpine species of the genus *Alpiscorpius* Gantenbein et al., 1999, stat. n. (Scorpiones: Euscorpiidae)

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Summary

Two subgenera of *Euscorpius* Thorell, 1876 (Scorpiones: Euscorpiidae) are elevated to the genus status: *Alpiscorpius* Gantenbein et al., 1999, **stat. n.** and *Tetratrachobothrius* Birula, 1917, **stat. n.** Seven new Alpine scorpion species are described and illustrated: *Alpiscorpius delta* **sp. n.** (Italy) from the “alpha group” (“*germanus* complex”); *A. kappa* **sp. n.** (Slovenia) and *A. lambda* **sp. n.** (Slovenia) from the “*germanus* group” (“*germanus* complex”); *A. omega* **sp. n.** (Slovenia), *A. omikron* **sp. n.** (Slovenia), *A. sigma* **sp. n.** (Italy, Slovenia), and *A. ypsilon* **sp. n.** (Austria, Slovenia) from the “gamma group” (“*mingrelicus* complex”). The taxonomic validity of these cryptic species is confirmed through cytogenetic and DNA analysis (Štundlová et al., 2019). *Alpiscorpius beta* (Di Caporiacco, 1950), **comb. n., stat. n.** (Italy, Switzerland) is restored from synonymy and elevated to species level within the “alpha group”. *Euscorpius germanus marcuzzii* Valle et al., 1971 (Italy), recently elevated to species level, is synonymized with *Alpiscorpius germanus* (C. L. Koch, 1837), **comb. n.** (which is found in Austria, Italy, and Switzerland but not in Slovenia). The genus *Alpiscorpius* currently includes 15 valid species (6 in “*germanus* complex” and 9 in “*mingrelicus* complex”). Many populations of *Alpiscorpius* spp. from the Balkan Peninsula, formerly listed under *Euscorpius gamma* or *E. mingrelicus*, remain unassigned.

Introduction

A Brief History of Study

Euscorpius germanus (C. L. Koch, 1837) has been originally described without an exact type locality, from “southern Tyrol [i.e. today’s South Tyrol, the northernmost province of Italy] and northern Italy”. This species traditionally included several subspecies with rather unclear diagnostic characters (Hadži, 1929; Capra, 1939; Di Caporiacco, 1950; Bonacina, 1980).

Gantenbein et al. (1999), based on DNA phylogeny (16S mtDNA marker), described the subgenus *Euscorpius* (*Alpiscorpius*), with *Euscorpius germanus* as its type species. Further, Gantenbein et al. (2000) designated the neotype of *Euscorpius germanus*, and confirmed parapatric *Euscorpius* (*Alpiscorpius*) *alpha* (Di Caporiacco, 1950), as a separate species based on the analyses of allozymes and mtDNA. The two species were clearly separated geographically, with the Adige (=Etsch) River as a boundary (see Gantenbein et al., 2000: 845 for the map). At the same time, they did not find reliable morphological characters to distinguish these two “cryptic” Alpine species.

Scherabon et al. (2000) elevated another former subspecies of *Euscorpius germanus* to species status as *Euscorpius gamma* (Di Caporiacco, 1950). This species belonged to the “*mingrelicus* complex”, which has a broad, disjunct range from the Eastern Alps to the Caucasus. Fet et al.

(2001) reviewed fauna of scorpions from Slovenia, including two *Euscorpius* (*Alpiscorpius*) species then addressed as *Euscorpius germanus* and *E. gamma*. Further DNA-based studies (Graham et al., 2012; Fet et al., 2016) indicated a high diversity of this genus in Europe and Anatolia, confirmed by a detailed morphological revision of three Anatolian species (Tropea et al., 2015).

The populations of *Euscorpius* (*Alpiscorpius*) spp. in the major part of the Balkan Peninsula remain unrevised. The taxonomic position of two valid species formerly associated with this subgenus is currently uncertain: *Euscorpius ciliciensis* Birula, 1898 from Turkey (Tropea et al., 2015: 22) and *E. croaticus* Di Caporiacco, 1950 from Croatia (Graham et al., 2012: 49).

Most recently, Štundlová et al. (2019) studied 73 populations of *Euscorpius* (*Alpiscorpius*) from the Alps using detailed cytogenetic and DNA analysis. This integrative study combining different data sources revealed a great and unexpected diversity within this scorpion group. Among 50 populations belonging to the “*germanus* complex”, they demonstrated the existence of four additional cryptic lineages (two related to *E. germanus*, and two, to *E. alpha*). Furthermore, among 23 populations of the “*mingrelicus* complex” (“*gamma* group”) from the Eastern Alps (Slovenia, Austria, Italy), Štundlová et al. (2019) demonstrated existence of another four new cryptic lineages related to *E. gamma*. In this paper,



Figure 1. *Alpiscorpius germanus*, female with newborn.

we examined the morphological traits of the *Euscorpium* (*Alpiscorpius*) specimens included in the cytogenetic and sequence-based analyses. Our examination showed that, despite apparent chromosomal and genetic differences, no exclusive, species-specific morphological characters defining the lineages were found. However, most cryptic species can be diagnosed on the basis of statistical analysis of countable traits (number of trichobothria and pectinal teeth; see Table 5). We assign the karyotypic races revealed by Štundlová et al. (2019) to the existing or new species, most of them allopatric.

Elevation of Subgenera

The subgeneric classification of the rapidly expanding genus *Euscorpium* Thorell, 1876 (which currently includes over 60 species) is long overdue for a revision. A subgenus is clearly not a practically useful category in scorpion systematics; in fact, we do not know of a single case when a genus was downgraded to a subgenus level. Scorpion subgenera in various families have been described very rarely, and are constantly elevated to the genus status, e.g. in the recent revisions of *Isometrus* (Buthidae) and *Pandinus* (Scorpionidae). A parallel trend is splitting of an overly inflated scorpion genus into several genera (but not into subgenera), e.g. in *Vaejovis* (Vaejovidae) and *Rhopalurus* (Buthidae) as a result of a detailed revision.

In *Euscorpium* Thorell, 1876, subgenera existed for a century now; they were first introduced by Birula (1917) as monotypic taxa to accommodate two morphologically distinct species, *Euscorpium* (*Polytrichobothrius*) *italicus* (Herbst, 1800) and *E.* (*Tetratrachobothrius*) *flavicaudis* (DeGeer, 1778). The subgenus *Euscorpium* (*Euscorpium*) Thorell, 1876 *s. str.* kept including newly described species until the very first DNA-based phylogeny (Gantenbein et al., 1999) led to the description of the subgenus *Euscorpium* (*Alpiscorpius*) Gantenbein et al., 1999.

Further DNA-based phylogenetic work on the genus *Euscorpium* (Graham et al., 2012; Parmakelis et al., 2013; Fet et al., 2016) constantly demonstrated separate position of two distinct clades corresponding to the subgenera, which we here elevate to genus status: *Alpiscorpius* Gantenbein et al., 1999, **stat. n.** (see below for new combinations of subordinate species names) as well as *Tetratrachobothrius* Birula, 1917, **stat. n.**, a monotypic genus, with type species *Tetratrachobothrius flavicaudis* (DeGeer, 1778), **comb. n.**

At the same time, the remaining large and heterogeneous subgenus *Euscorpium* Thorell, 1876, *s. str.* is not monophyletic (Tropea, 2013; Parmakelis et al., 2013), and the elevation of the subgenus *Polytrichobothrius* Birula, 1917 will require descriptions of new genus-level names within the current *Euscorpium* Thorell, 1876, *s. str.*

Methods, Material & Abbreviations

“Material Examined” section below includes only the specimens used in cytogenetic and DNA analyses; among them are all type specimens of new species. Nomenclature and measurements follow Stahnke (1971), Kovařík (2009), and Kovařík & Ojanguren Affilastro (2013), except for trichobothriotaxy (Vachon, 1974). Specimens studied herein are preserved in 80% or 97% ethanol.

Specimen depositories: MCSNB, Museo Civico di Scienze Naturali “Enrico Caffi”, Bergamo, Italy; MZUF, Museo di Storia Naturale dell’Università di Firenze, Sezione di Zoologia “La Specola”, Florence, Italy; NMBS, Naturhistorisches Museum Bern, Bern, Switzerland; NMPC, National Museum of Natural History, Prague, Czech Republic.

Abbreviations: Dp, pectinal teeth; Pv, patellar trichobothria, ventral series; *et*, patellar trichobothria, external terminal group; *eb_a*, patellar trichobothria, external basal-a group.

Systematics

Family *Euscorpiidae* Laurie, 1896

DIAGNOSIS: Inner accessory denticles present on pedipalp chelal fingers. Outer denticles of pedipalp chelal fingers are displaced to outer aspect of fingers. Pedipalp chelal finger median denticles aligned in straight row. Pedipalp chela is flat in appearance. Trichobothrial pattern type C. Two subdistal denticles present on cheliceral movable finger dorsal edge. Ventral edge of cheliceral movable finger either smooth or with crenulations; serrula is absent. Two pedal spurs present on legs. Tarsal spurs on legs absent. Sternum pentagonal in shape. Hemispermatophore lamelliform in shape. Telson without subaculear tubercle.

Genus *Alpiscorpius* Gantenbein, Fet, Largiadèr & Scholl, 1999, **stat. n.**

(Figures 1–71, Tables 1–5)

<http://zoobank.org/urn:lsid:zoobank.org:act:8B1B5643-98A4-4C2D-9A23-02D95044B401>

Euscorpius (*Alpiscorpius*) Gantenbein, Fet, Largiadèr & Scholl, 1999: 55.

DIAGNOSIS: Movable fingers of pedipalps chela with denticles in a single row. Movable fingers bear 7 rows of denticles with inner and outer denticles. Outer accessory denticles (OAD) on chelal fingers are not present; inner accessory denticles (IAD) of chelal movable finger are paired with five inner denticles, without exhibiting other inner accessory denticles. Cheliceral movable finger dorsal edge with two small subdistal (*sd*) denticles; ventral edge smooth. Ventral distal denticle (*vd*) conspicuously longer than dorsal (*dd*). Cheliceral fixed finger with four denticles, median (*m*) and basal (*b*) denticles conjoined on common trunk; no ventral accessory denticles present. Ventral edge of cheliceral movable finger

smooth; serrula is absent. Patella of pedipalp with 3 external trichobothria in *em* group. Dorsal Patellar Spur (DPS) is not well developed, but instead very reduced (Soleglad & Sissom, 2001, figs. 149, 150). The telson vesicle of sexually mature males is not symmetrically swollen from a lateral aspect, but swollen more at the base, tapering towards the elongated aculeus, which lacks any trace of a subaculear tubercle (as defined by the subaculear setal pair) (Soleglad & Sissom, 2001, figs. 179, 180). The ventral median spinule row of leg tarsus does not terminate in a pair of well-developed spinules but instead terminates in an offset single spinule (Soleglad & Sissom, 2001, Table 6).

TYPE SPECIES: *Scorpius germanus* C. L. Koch, 1837.

COMMENTS. We subdivide all valid species of the genus *Alpiscorpius* Gantenbein et al., 1999 into two informal complexes, which form monophyletic clades (Scherabon et al., 2000; Graham et al., 2012; Fet et al., 2016; Štundlová et al., 2019): “*germanus* complex” and “*mingrelicus* complex”. Morphologically, these clades are easily diagnosed by the position of pedipalp fixed finger trichobothria *et*, *est*, and *dsb* (see diagnosis and Figs. 44 versus 8). This character, quantified as *et-est/est-dsb* distance ratio, was first introduced by Bonacina (1980). It is useful to distinguish two complexes (especially when their species are sympatric, e.g. in Slovenia); however, a broad intraspecific variation makes it difficult to apply the *et-est/est-dsb* ratio to distinguishing related species. For example, Fet & Braunwalder (2005) calculated *et-est/est-dsb* ratio for *E. germanus* from Val Müstair population (Switzerland), which had mean 1.14, SD= 0.16 (n=88), and Tropea et al. (2015: 23) reported a mean *et-est/est-dsb* ratio in examined *E. germanus* specimens as 1.16, with a range of 0.90–1.33. For three Anatolian-Caucasian species of the “*mingrelicus* complex”, Tropea et al. (2015) reported a wide variation, with a mean ratio of 1.8 to 2.4, and a range of 1.69 to 3.23.

Including new taxa described in this paper, the “*germanus* complex” currently comprises 6 valid species, all endemic to the Alps (Austria, Italy, Slovenia, and Switzerland; Fig. 71); all these species were analyzed by Štundlová et al. (2019). The “*mingrelicus* complex” currently includes 9 valid species inhabiting the large region covering the Eastern Alps (Austria, Italy, Slovenia), part of the Balkan Peninsula, Anatolia, and the Caucasus Mts. (northeast Turkey, Georgia, Russia). A detailed revision of the Anatolian-Caucasian taxa was recently published by Tropea et al. (2015). The European (mostly Balkan) populations of this complex remain unrevised (Graham et al., 2012).

In addition to the *et-est/est-dsb* ratio, members of the “*mingrelicus* complex” were traditionally differentiated from the “*germanus* complex” by fine to strong granulation on the ventral surface of metasoma V, which is smooth in all members of the “*germanus* complex” (Di Caporiacco, 1950; Graham et al., 2012). However, three of the four new Alpine species of the “*mingrelicus* complex” described here, have metasoma V ventral surface almost smooth; only the fourth species *A. sigma* **sp. n.**, has metasoma V finely granulated (Figs. 46–47 versus 51–52).

Taxa	Karyotype (Štundlová et al., 2019)	Distribution
“ <i>germanus</i> complex”		
“ <i>alpha</i> group” (Italy, Switzerland)		
<i>Alpiscorpius alpha</i> (Di Caporiacco, 1950), comb. n.	Karyotypic race II (Eal 90), 2n=90	Italy (Lombardy) Switzerland (Ticino, Grisons)
<i>Alpiscorpius beta</i> (Di Caporiacco, 1950), comb. n., stat. n.	Karyotypic race I (Eal 60), 2n=60	Italy (Piedmont, Val d’Aosta), Switzerland (Valais)
<i>Alpiscorpius delta</i> sp. n.	Karyotypic race III (Eal 54), 2n=54	Italy (Lombardy, South Tyrol, Trentino, Veneto)
“ <i>germanus</i> group” (Italy, Austria, Switzerland, Slovenia)		
<i>Alpiscorpius germanus</i> (C. L. Koch, 1837), comb. n.	Karyotypic race I (Ege46a), 2n=46	Italy (Friuli-Venetia Giulia, South Tyrol, Trentino, Veneto) Austria, Switzerland (Grisons)
<i>Alpiscorpius kappa</i> sp. n.	Karyotypic race III (Ege46c), 2n=46	Slovenia (Gorenjska, Goriška)
<i>Alpiscorpius lambda</i> sp. n.	Karyotypic race II (Ege46b), 2n=46	Slovenia (Goriška, Notranjska), ?Italy
“ <i>mingrelicus</i> complex” (Europe)		
“ <i>gamma</i> group”*		
<i>Alpiscorpius beroni</i> (Fet, 2000), comb. n.	Unknown	Albania
<i>Alpiscorpius gamma</i> (Di Caporiacco, 1950), comb. n.	2n=78	Slovenia (Goriška); ?Italy; ?Croatia
<i>Alpiscorpius omega</i> sp. n.	Karyotypic race IV (Ega 88), 2n=88	Slovenia (Dolenjska, Gorenjska, Štajerska)
<i>Alpiscorpius omikron</i> sp. n.	Karyotypic race II (Ega58), 2n=58	Slovenia (Gorenjska)
<i>Alpiscorpius sigma</i> sp. n.	Karyotypic race II (Ega60), 2n=60	Italy (Friuli-Venezia Giulia), Slovenia (Gorenjska)
<i>Alpiscorpius ypsilon</i> sp. n.	Karyotypic race III (Ega86-92), 2n=86 to 92	Austria, Slovenia (Gorenjska, Štajerska)
* <i>Alpiscorpius</i> spp. recorded from the Balkans (Bosnia & Herzegovina, Bulgaria, Croatia, Kosovo, Montenegro, North Macedonia, Serbia), formerly listed under <i>Euscorpium gamma</i> or <i>E. mingrelicus</i> , are currently unrevised and unassigned.		
“ <i>mingrelicus</i> group” (Anatolia and Caucasus)		
<i>Alpiscorpius mingrelicus</i> (Kessler, 1874), comb. n.	Unknown	Georgia, Russia (North Caucasus), Turkey
<i>Alpiscorpius phrygius</i> (Bonacina, 1980), comb. n.	Unknown	Turkey
<i>Alpiscorpius uludagensis</i> (Lacroix, 1995), comb. n.	Unknown	Turkey

Table 1. The currently valid *Alpiscorpius* taxa, their karyotypes, and distribution.

“*germanus* complex”

DIAGNOSIS: Total length of adults 18–30 mm. Pedipalp chela with 4 trichobothria ($3V$, Et_1) on ventral surface. Patella of pedipalp with 3 external trichobothria in *em* group, 4–5 external trichobothria in *et* group, and 5–6 ventral trichobothria. Pedipalp chela fixed finger with trichobothrium *est* located approximately between trichobothria *et* and *dsb* (Fig. 8), i.e. *et-est/est-dsb* distance ratio is about 1. Metasomal segment V smooth, without granulation or carinae.

COMPOSITION. We subdivide all valid species of the “*germanus* complex” into two informal groups: “*alpha* group” and “*germanus* group” according to their DNA phylogeny and karyotypic identity (Gantenbein et al., 2000; Štundlová et

al., 2019). Geographic distribution of these two groups is continuous and limited to the Alpine area of Europe.

SUBORDINATE TAXA (6 SPECIES).

“*alpha* group”:

Alpiscorpius alpha (Di Caporiacco, 1950), **comb. n.** (Italy, Switzerland)

A. beta (Di Caporiacco, 1950), **comb. n., stat. n.** (Italy, Switzerland)

A. delta **sp. n.** (Italy)

“*germanus* group”:

A. germanus (C. L. Koch, 1837), **comb. n.** (Austria, Italy, Switzerland)

A. kappa **sp. n.** (Slovenia)

A. lambda **sp. n.** (Slovenia, ?Italy)

“*alpha* group”*Alpiscorpius alpha* (Di Caporiacco, 1950), **comb. n.**

(Figures 2–6, 71, Tables 1, 5)

<http://zoobank.org/urn:lsid:zoobank.org:act:45C8FC9A-512F-4BE9-8ADD-5894E8FC9E69>*Euscorpius germanus* “forma A”: Capra, 1939: 203.*Euscorpius germanus alpha* Di Caporiacco, 1950: 211; Bonacina, 1980: 58 (in part).*Euscorpius (Euscorpius) germanus alpha*: Fet & Sissom, 2000: 366–368 (in part; complete references list until 1998).*Euscorpius alpha*: Gantenbein et al., 2000: 858 (in part); Braunwalder, 2001: 281 (in part); Soleglad & Sissom, 2001: 90; Fet et al., 2004: 55 (in part); Colombo, 2006: 3 (in part); Vignoli & Salomone, 2008: 206 (in part); Fet, 2010: 6 (in part); Tropea et al., 2015: 3.*Euscorpius (Alpiscorpius) alpha*: Fet & Braunwalder, 2005: 34 (in part).*Euscorpius (Alpiscorpius) alpha* Karyotypic race II (Eal 90): Štundlová et al., 2019: 156.

TYPE LOCALITY AND TYPE DEPOSITORY. **Italy**: Lombardy, Lago di Como near Varenna; lectotype ♀ designated by Gantenbein et al. (2000: 858) (MZUF 5569). Paralectotypes: type locality, 1♂ (MZUF 5571), 5♀ (MZUF 5568, 5570–5574); Lombardy, Varese, 6♂5♀ (MZUF 5584–5585); Trentino, Monte Stelvio, 1♀ (MZUF 5567) [most likely *A. delta* sp. n.].

MATERIAL EXAMINED (NMPC): 23♂11♀. **Italy**: Lombardy, Crespineto, 46.155°N10.098°E, 1♂ (S462); Domaso, 46.157°N9.328°E, 2♂ (S426, S523) 1♀; Mezzoldo, 46.016°N9.665°E, 3♂1♀ (S180, S182, S253, S275) 1♀; Nuova Olomio, 46.161°N9.433°E, 1♂ (S026); Olmo al Brembo, 45.973°N9.650°E, 1♂ (S580) 1♀ (S627); Puria, 46.032°N9.048°E, 3♂ (S439, S469, S521) 1♂4♀; Selvetta, 46.157°N9.682°E, 2♂ (S464, S524); Sondrio, 46.175°N9.857°E, 1♂ (S284); Teglio, 46.182°N10.052°E, 3♂ (S433, S438, S447) 1♀; Varenna, 46.009°N9.288°E, 1♂ (S846). **Switzerland**: Grisons, Sottoponte, 46.339°N9.555°E, 1♂ (S576) 2♀. Ticino, Castel San Pietro, 45.860°N9.017°E, 2♂ (S064, S066); Somazzo, 45.884°N8.996°E, 1♂ (S1076).

DIAGNOSIS. We limit *Alpiscorpius alpha* (Di Caporiacco, 1950) to the “Karyotypic race II (Eal 90)” defined by Štundlová et al. (2019), which has 2n = 90 chromosomes. The karyotype is composed of 10 metacentric, 10 submetacentric, 2 subtelocentric, and 68 telocentric chromosomes (fig. S1B in Štundlová et al., 2019). The rDNA clusters are localized in the subterminal region of the long arms of the telocentric chromosome pair 21 (fig. 2B and fig. S1B in Štundlová et al., 2019). Number of pectinal teeth (Dp) in male usually 7 (>80% of examined specimens). Number of patellar ventral trichobothria (Pv) usually 6 (80%). Reduction of patellar external trichobothria from 4 to 3 common in series *et* (>10%) and very common in series *eb_a* (>25%).

VARIABILITY. We scored standard phenotypic markers for 23 examined specimens (22♂, 1♀), with the following variation observed:

Dp in males (n=22): 0/7 (1), 2/7 (1), 6/5 (1), 6/6 (3), 7/6 (1), 7/7 (14), 8/7 (1); in total (not counting aberrant pectines), 5 in 2.38% (1), 6 in 14.29% (6); 7 in 83.33% (35), and 8 in 2.38% (1); mean = 6.84, SD = 0.48.

Dp in females (n=1): 6/6.

Pv (n=23): 6/4 (1), 6/5 (5), 6/6 (15), 6/7 (1), 7/5 (1); in total, 4 in 2.17% (1), 5 in 13.04% (6), 6 in 80.43% (37) and 7 in 4.38% (2); mean = 5.87, SD = 0.50.

et (n=23): 3/4 (2), 4/3 (3), 4/4 (16), 5/4 (2); in total, 3 in 10.87% (5), 4 in 84.78% (39), 5 in 4.35% (2); mean = 3.93, SD = 0.39.

eb_a (n=23): 3/3 (3), 3/4 (2), 4/3 (4), 4/4 (14); in total, 3 in 26.09% (12) and 4 in 73.91% (34); mean = 3.74, SD = 0.44.

DISTRIBUTION. Italy (Lombardy), Switzerland (Grisons, Ticino) (Fig. 71).

NOTES. Populations of *A. alpha* (then addressed as *Euscorpius germanus alpha* or *E. alpha*) from Italy and Switzerland were studied by Bonacina (1980), Gantenbein et al. (2000), Braunwalder (2001), and Fet & Braunwalder (2005). Here, we establish two more species, populations of which were formerly listed under “*Euscorpius alpha*”: *Alpiscorpius beta* (Di Caporiacco, 1950), **comb. n.**, **stat. n.** (found to the west from *A. alpha*) and a new species, *Alpiscorpius delta* sp. n. (found to the east from *A. alpha*) (Fig. 1). Since *A. alpha* is significantly restricted in our study, the Italian populations studied by Bonacina (1980) should be reassessed, and their phenotypic markers scored from the material deposited in MCSNB.

Some of the previously studied populations of *A. alpha* were the same as analyzed by Štundlová et al. (2019) such as Sottoponte (Grisons), Olmo al Brembo, Sondrio (Lombardy). Gantenbein et al. (2000) published 16S mtDNA sequences for six populations of “*Euscorpius (Alpiscorpius) alpha*” (Switzerland: Ticino: Rancate; Grisons: Sottoponte; Italy: Lombardy: San Pellegrino, San Giovanni Bianco, Olmo al Brembo, Carona), which closely match DNA sequences of Eal 90 (= *A. alpha*) obtained independently by Štundlová et al. (2019). At the same time, 16S mtDNA sequences of other three populations of “*E. (A.) alpha*” further west and northwest published by Gantenbein et al. (2000) (Italy: Lombardy: Tavernola; Trentino: Molino di Ledro; South Tyrol: Marling) closely match Eal 54 (= *A. delta* sp. n., see below).

Morphological variation was found to exist within *Euscorpius alpha* (Gantenbein et al., 2000; Fet & Braunwalder, 2005) but was inconclusive to support the species’ diagnosis. However, some of the populations formerly included under *A. alpha* are treated here as two more cryptic species: *Alpiscorpius beta* (Di Caporiacco, 1950) and *A. delta* sp. n. With *A. alpha* limited to its current scope, there are indeed phenotypic markers, which, in combination with geographic distribution, can be used to identify *A. alpha* (Tab. 5).



Alpiscorpius alpha **comb. n.**



Alpiscorpius germanus **comb. n.**

Figures 2–12: *Alpiscorpius alpha* **comb. n.**, male (2–6, No. S462) from Italy, Crespino, 46.155°N10.098°E and *A. germanus* **comb. n.**, male (7–12, S444) from Italy, Quellenhof, 46.747°N 11.216°E. **Figures 2–4, 7–10.** Pedipalp chela and patella dorsal (2, 7), external (3, 8), and ventral (4, 9) views, femur and trochanter dorsal (10). The trichobothrial pattern is indicated in Figures 7–10. **Figures 5–6, 11–12.** Metasoma III–V and telson, ventral (5, 11), and lateral (6, 12) views.

Dimensions (mm)		<i>A. beta</i> comb.n.	<i>A. delta</i> sp. n.	<i>A. kappa</i> sp. n.	<i>A. lambda</i> sp. n.
		♂	♂ holotype	♂ holotype	♂ holotype
Carapace	L / W	4.212 / 4.062	3.522 / 3.284	3.756 / 3.533	3.516 / 3.626
Mesosoma	L	6.113	5.557	6.187	5.181
Tergite VII	L / W	1.740 / 2.746	1.046 / 2.349	1.717 / 2.833	1.027 / 2.926
Metasoma + telson	L	13.874	11.832	12.721	12.436
Segment I	L / W / D	1.132 / 1.463 / 1.228	1.025 / 1.202 / 1.026	1.256 / 1.380 / 1.211	1.142 / 1.484 / 1.224
Segment II	L / W / D	1.479 / 1.265 / 1.129	1.218 / 1.082 / 1.030	1.446 / 1.184 / 1.144	1.339 / 1.301 / 1.105
Segment III	L / W / D	1.555 / 1.206 / 1.098	1.333 / 1.039 / 1.000	1.589 / 1.173 / 1.088	1.528 / 1.260 / 1.067
Segment IV	L / W / D	1.783 / 1.006 / 0.959	1.718 / 0.995 / 0.955	1.860 / 1.133 / 1.097	1.785 / 1.173 / 0.992
Segment V	L / W / D	3.637 / 1.153 / 1.026	2.876 / 1.075 / 0.997	3.184 / 1.289 / 1.139	3.156 / 1.313 / 1.034
Telson	L / W / D	4.288 / 1.709 / 1.411	3.662 / 1.758 / 1.602	3.386 / 1.563 / 1.379	3.486 / 1.634 / 1.350
Pedipalp	L	15.444	11.562	13.723	13.638
Femur	L / W	3.485 / 1.240	2.855 / 0.990	3.315 / 1.186	3.227 / 1.183
Patella	L / W	3.939 / 1.429	2.930 / 1.188	3.533 / 1.373	3.553 / 1.436
Chela	L	8.020	5.777	6.875	6.858
Manus	W / D	2.944 / 2.201	2.426 / 2.090	2.570 / 2.074	2.597 / 2.157
Movable finger	L	4.747	3.314	3.950	3.967
Total	L	24.199	20.911	22.664	21.133

Table 2. Comparative measurements of *Alpiscorpius beta* comb. n., male (No. S102) from Switzerland, Gondo, 46.195°N 8.137°E, *A. delta* sp. n., *A. kappa* sp. n., and *A. lambda* sp. n., male holotypes. Abbreviations: length (L), width (W, in carapace it corresponds to posterior width), depth (D).

Fet & Braunwalder (2005) scored phenotypic markers for a large series (>250 specimens) of this species from four populations in Switzerland, in the cantons of Ticino (Lugano, Mendrisio) and Grisons (Val Bregaglia, Val Poschiavo), with the following results:

Dp in males (n=87); in total, mean= 6.74, SD= 0.65.

Dp in females (n=161): mean= 5.76, SD= 0.58.

Pv (n=255): mean = 6.00, SD= 0.29.

et (n=244): 3 in 2.25% (11), 4 in 97.13% (474), 5 in 0.6% (3); mean = 3.98, SD = 0.17.

These phenotypic data are consistent with the 23 examined specimens used for karyotype and DNA phylogeny study by Štundlová et al. (2019). Note that the Swiss populations, which are found at the northern margin of the species' range, appear to be less diverse than Italian populations in having low frequency of *et*=3 reduction (ca. 2%).

Alpiscorpius beta (Di Caporiacco, 1950), **comb. n., stat. n.**

(Figures 13–17, 71, Tables 1, 2, 5)

<http://zoobank.org/urn:lsid:zoobank.org:act:02256D81-6FBF-46C0-BB92-5B23BD676CA5>

Euscorpius germanus “forma B”: Capra, 1939: 204.

Euscorpius germanus beta Di Caporiacco, 1950: 211.

Euscorpius germanus germanus: Bonacina, 1980: 58 (in part).

Euscorpius (Euscorpius) germanus alpha: Fet & Sissom, 2000: 366–368 (in part).

Euscorpius (Alpiscorpius) alpha: Gantenbein et al., 2000: 858 (in part; Gondo, Fountainmore); Fet & Braunwalder, 2005: 34 (in part; Gondo, Zwischbergental).

Euscorpius alpha: Braunwalder, 2001: 281 (in part; Gondo, Zwischbergental); Vignoli & Salomone, 2008: 206 (in part); Fet, 2010: 6 (in part).

Euscorpius (Alpiscorpius) alpha Karyotypic race I (Eal 60): Štundlová et al., 2019: 155.

TYPE LOCALITY AND TYPE DEPOSITORY. Italy, Piedmont: Novara, Monte Massone, [45.947°N, 8.337°E] (MZUF 5588), lectotype ♂ designated by Gantenbein et al. (2000: 856, 858). Paralectotypes: 5♂5♀ (MZUF 5589-5593), type locality; 1♂1♀ (MZUF 5584-5585), Colle della Piccola Mologna, 2000 m; 2♀ (MZUF), Lamorano.

MATERIAL EXAMINED (NMPC): 4♂8♀. **Italy, Piedmont:** Tavigliano, 45.662°N 8.072°E, 1♀ (S647); Loreglia, 45.902°N 8.370°E, 2♂(S589-S590) 1♂3♀; **Val d'Aosta:** Antey-St André, 45.788°N 7.589°E, 1♂ (S098). **Switzerland, Valais:** Gondo, 46.195°N 8.137°E, 2♂ (S547, 589) 1♀ (S637) 3♀.

DIAGNOSIS. *Alpiscorpius beta* is a cryptic species of the “alpha group” of the “germanus complex” defined by Štundlová et al. (2019) as “Karyotypic race I (Eal 60)”, which has 2n = 60 chromosomes. The karyotype is composed of 34 metacentric, 14 submetacentric, 2 subtelocentric, and 10 telocentric chromosomes (fig. S1A in Štundlová et al., 2019). The rDNA clusters are localized in the subterminal region of the long arms



Alpiscorpius beta comb. n., stat. n.



Alpiscorpius delta sp. n.

Figures 13–22: *Alpiscorpius beta* comb. n., stat. n., male (13–17, No. S102) from Switzerland, Gondo, 46.195°N 8.137°E and *Alpiscorpius delta* sp. n., male holotype (18–22, No. S277). **Figures 13–15, 18–20.** Pedipalp chela and patella dorsal (13, 18), external (14, 19), and ventral (15, 20) views. **Figures 16–17, 21–22.** Metasoma III–V and telson, ventral (16, 21), and lateral (17, 22) views.

of the metacentric chromosome pair 4 (fig. 2A and fig. S1A in Štundlová et al., 2019). Number of pectinal teeth (Dp) in male usually 8. Number of patellar ventral trichobothria (P_v) varies from 5 to 6. Reduction of patellar external trichobothria from 4 to 3 rare in series *et* (<10%) and more common in series eb_a (>10%); see also Notes.

DESCRIPTION OF THE MALE. The following description is based primarily on a male from Gondo, Switzerland. Measurements of this specimen are presented in Table 1. Carapace, tergites, and pedipalps reddish-brown; carapace with some darker mottling; metasoma dark reddish-brown with dark mottling; telson, legs, and sternites dark yellow to reddish-brown; chelicerae light, slightly reticulated. Anterior edge of carapace essentially straight; smooth and lustrous, lacking any indication of carinae. There are two lateral eyes. Median eyes and tubercle are small in size. Tergites I–VII essentially smooth; tergite VII lacking lateral and median carinal pairs. Sternites III–VII smooth and lustrous; VII lacking lateral and median carinae. Stigmata are small, narrow elliptical. Metasomal segment V smooth without granulation and carinae. Vesicle of telson swollen and elongated, with short highly curved aculeus. Vesicle essentially void of granules, lustrous. Pectinal teeth number 8/7. Pedipalp carinae well-developed (Figs. 13–15). Trichobothrial pattern type C, neobothriotaxic: chela ventral = 4/4; patellar $eb = 4/5$, $eb_a = 4/4$, $esb = 2/2$, $em = 3/3$, $est = 3/3$, $et = 4/5$; patellar ventral = 5/5. Tarsus of legs with single row of spinules on ventral surface.

VARIABILITY. We scored standard phenotypic markers for 7 examined specimens (5♂, 2♀), with the following variation observed:

Dp in males (n=5): 7/7 (1), 8/8 (3), 8/9 (1); in total, 7 in 20% (2), 8 in 70% (7) and 9 in 10% (1); mean = 7.90, SD = 0.57.

Dp in females (n=2): 6/4 (1), 6/6 (1).

P_v (n=7): 5/5 (3), 5/6 (1), 6/5 (1), 6/6 (2); in total, 5 in 57.14% (8), and 6 in 42.86% (6); mean = 5.43, SD = 0.51.

et (n=7): 4/3 (1), 4/4 (13); in total, 3 in 7.14% (1), and 4 in 92.86% (13); mean = 3.93, SD = 0.27.

eb_a (n=7): 4/3 (2), 4/4 (12); in total, 3 in 14.29% (2) and 4 in 85.71% (12); mean = 3.86, SD = 0.36.

DISTRIBUTION. Italy (Piedmont, Val d'Aosta), Switzerland (Valais: Zwischbergental) (Fig. 71).

NOTES. This taxon was first informally delineated by Capra (1939) as “Form B” from Val d'Aosta, including the marginal, westernmost populations of “*Euscorpius germanus*” (sensu lato). It was formally described as a subspecies by Di Caporiacco (1950). Bonacina (1980) synonymized *E. g. beta* with *E. g. germanus* and noted that both taxa had five trichobothria on ventral aspect of patella ($P_v=5$). This synonymy, however, created a disjunct distribution for *E. g. germanus* sensu Bonacina (1980). Italian populations studied by Bonacina (1980) should be reassessed, and their phenotypic markers scored from the material deposited in MCSNB.

Populations from Fontainemore (Val d'Aosta, Italy) and Gondo, on the Simplon Pass road (Switzerland, Valais) were studied by Gantenbein et al. (2000) who synonymized *E. germanus beta* with *E. alpha*. The Gondo (or Simplon) population was studied in more detail by Braunwalder (2001) and Fet & Braunwalder (2005).

Gantenbein et al. (2000) published a 16S mtDNA sequence (AJ389379), identical for Gondo and Fontainemore populations, which closely matches those of Eal 60 (= *A. beta*) obtained independently by Štundlová et al. (2019).

Following Gantenbein et al. (2000), both Braunwalder (2001) and Fet & Braunwalder (2005) addressed the Swiss population from Simplon as *E. alpha*. However, both Gantenbein et al. (2000) and Fet & Braunwalder (2005) noted morphological features ($P_v=5$ to 6, mean 5.40) distinguishing it from the more eastern Swiss populations of *E. alpha* (Ticino, Grisons), which usually had $P_v=6$.

Fet & Braunwalder (2005) scored the standard phenotypic markers for 25 specimens of this species from Switzerland (Simplon), with the following results:

Dp in males (n=6): mean=8.17, SD=0.58.

Dp in females (n=17): mean = 6.71, SD= 0.52,

P_v (n=25): mean = 5.40, SD= 0.50,

et (n=23): 3 in 2.17% (1), and 4 in 97.83% (45); mean = 3.98, SD = 0.15.

These data are consistent with the 7 examined specimens used for karyotype and DNA phylogeny study by Štundlová et al. (2019). We confirm that males indeed have a higher Dp value than *A. alpha* (8 vs. 7), P_v varies between 5 and 6, and reduction of *et* from 4 to 3 is rare (ca. 2%, only one case out of 46 scored pedipalps).

Alpiscorpius delta sp. n.

(Figures 18–22, 71, Tables 1, 2, 5)

<http://zoobank.org/urn:lsid:zoobank.org:act:1716EDF0-644D-4E76-865C-F1A39CADA178>

Euscorpius germanus alpha: Di Caporiacco, 1950: 211 (in part); Bonacina, 1980: 58 (in part).

Euscorpius (Euscorpius) germanus alpha: Fet & Sissom, 2000: 366–368 (in part).

Euscorpius (Alpiscorpius) alpha: Gantenbein et al., 2000: 858 (in part).

Euscorpius alpha: Colombo, 2006: 3 (in part; Brescia); Fet et al., 2004: 55 (in part); Vignoli & Salomone, 2008: 206 (in part); Fet, 2010: 6 (in part).

Euscorpius (Alpiscorpius) alpha Karyotypic race III (Eal 54): Štundlová et al., 2019: 156.

TYPE LOCALITY AND TYPE DEPOSITORY. Italy, Trentino: Pannone, 45.871°N 10.933°E; NMPC.

TYPE MATERIAL (NMPC): 27♂17♀. Italy, Lombardy: Brescia, Monte Mondero, 45.777°N 10.183°E, 2♂ (paratype Nos. S427, S476) 2♀ (paratypes); Pezzoro, 45.763°N 10.223°E, 1♂ (paratype No. S287); Ponte Caffaro, 45.817°N 10.515°E,

2♂ (paratypes Nos. S456, S457), 2♂4♀ (paratypes); Sonvico, 45.819°N 10.131°E, 6♂ (paratypes Nos. S183, S262, S282, S465, S466, S467) 1♂ (paratype). *South Tyrol*: Bad Salz (Bagni di Salto), 46.570°N 10.790°E, 1♂ (paratype No. S181) 1♀ (paratype); Baslan, 46.640°N 11.135°E, 1♂ (paratype No. S443); Tablá, 46.631°N 10.971°E, 1♂1♀ (paratypes Nos. S1075, S1034). *Trentino*: Pannone, 45.871°N 10.933°E, 3♂ (holotype No. S277, paratypes Nos. S458, S478) 2♂8♀ (paratypes); Tret, 46.468°N 11.147°E, 2♂ (paratypes No. S431, S476) 1♂1♀ (paratypes); Vermiglio, 46.290°N 10.678°E, 1♂ (paratype No. S579) 1♀ (paratype). *Veneto*, Lumini, 45.623°N 10.764°E, 1♂ (paratype No. S288).

ETYMOLOGY. Di Caporiacco (1950) named three subspecies of *Euscorpius germanus* after the letters of the Greek alphabet *alpha*, *beta*, and *gamma*. We continue in this style for another cryptic species and name it *delta* after Greek “δέλτα”.

DIAGNOSIS. *Alpiscorpius delta* sp. n. is a cryptic species of the “*alpha* group” of the “*germanus* complex”, defined by Štundlová et al. (2019) as “Karyotypic race III (Eal 54)”, which has 2n = 54 chromosomes. The karyotype is composed of 38 metacentric, 12 submetacentric, 2 subtelocentric, and 2 telocentric chromosomes (fig. S1C in Štundlová et al., 2019). The rDNA clusters are localized in the subterminal region of the long arms of the submetacentric chromosome pair 23 (fig. 2C and fig. S1C in Štundlová et al., 2019). Number of pectinal teeth (Dp) in male usually 7 (75% of examined specimens). Number of patellar ventral trichobothria (Pv) usually 5 (83%). Reduction of patellar external trichobothria from 4 to 3 rare in series *et* (<10%) and more common in series *eb_a* (>10%).

DESCRIPTION OF THE MALE HOLOTYPE. The following description is based primarily on the holotype male. Measurements of the holotype are presented in Table 1. Carapace, tergites, and pedipalps reddish-brown; carapace with some darker mottling; metasoma dark reddish-brown with dark mottling; telson, legs, and sternites dark yellow to reddish-brown; chelicerae light, slightly reticulated. Anterior edge of carapace essentially straight; smooth and lustrous, lacking any indication of carinae. There are two lateral eyes. Median eyes and tubercle are small in size. Tergites I–VII essentially smooth; tergite VII lacking lateral and median carinal pairs. Sternites III–VII smooth and lustrous; VII lacking lateral and median carinae. Stigmata are small, narrow elliptical. Metasomal segment V smooth without granulation and carinae. Vesicle of telson swollen and elongated, with short highly curved aculeus. Vesicle essentially void of granules, lustrous. Pectinal teeth number 7/7. Pedipalp carinae well-developed (Figs. 18–20). Movable fingers bear 7 rows of denticles with external and internal denticles. Trichobothrial patterns type C, neobothriotaxic: chela ventral = 4/4; patellar *eb* = 4/4, *eb_a* = 4/4, *esb* = 2/2, *em* = 3/3, *est* = 3/3, *et* = 5/5; patellar ventral = 5/5. Tarsus of legs with single row of spinules on ventral surface.

VARIABILITY. We scored standard phenotypic markers for 20 examined specimens (all ♂), with the following variation observed:

Dp in males (n=20): 6/6 (1), 6/7 (2), 7/7 (13), 8/7 (2), 8/8 (2); in total, 6 in 10% (4); 7 in 75% (30), and 8 in 15% (6); mean = 7.90, SD = 0.57.

Pv (n=20): 3/5 (1), 5/5 (15), 5/6 (1), 6/5 (2), 6/6 (1); in total (n=39, not counting one aberrant pectine with *Pv*=3), 5 in 82.5% (33), and 6 in 15.0% (5); mean = 5.15, SD = 0.37.

et (n=20): 3/4 (1), 4/3 (1), 4/4 (17), 5/5 (1); in total, 3 in 5% (2), 4 in 90% (36), 5 in 5% (2); mean = 4.00, SD = 0.32.

eb_a (n=19): 4/3 (4), 4/4 (15); in total, 3 in 10.53% (4) and 4 in 89.47% (34); mean = 3.92, SD = 0.27.

DISTRIBUTION. Italy (west of the Adige River: Lombardy, South Tyrol, Trentino, Veneto) (Fig. 71).

NOTES. This new species includes populations formerly listed under *Euscorpius alpha* (eastern part of its range). Gantenbein et al. (2000) published 16S mtDNA sequences for three populations of this species under “*Euscorpius (Alpiscorpius) alpha*” (Italy: *Lombardy*: Tavernola; *Trentino*: Molino di Ledro; *South Tyrol*: Marling) that closely match Eal 54 (= *A. delta* sp. n.). The Italian populations studied by Bonacina (1980) should be reassessed, and their phenotypic markers scored from the material deposited in MCSNB.

“*germanus* group”

Alpiscorpius germanus (C. L. Koch, 1837), **comb. n.**

(Figures 7–12, 71, Tables 1, 4, 5)

<http://zoobank.org/urn:lsid:zoobank.org:act:C0E34258-E851-48CC-9692-128CDE8226E5>

Scorpius germanus C. L. Koch, 1837: 110–112, pl. CVIII, figs. 250–252.

Euscorpius germanus “forma tipica”: Capra, 1939: 203.

Euscorpius germanus germanus: Di Caporiacco, 1950: 211 (in part); Bonacina, 1980: 58; Fet et al., 2004: 55 (in part).

Euscorpius germanus marcuzzii: Valle et al., 1971: 96 (in part); Bonacina, 1980: 58 (in part); Fet et al., 2004: 55 (in part).

Euscorpius germanus “T-Form”: Scherabon, 1987: 87.

Euscorpius (Alpiscorpius) germanus: Gantenbein et al., 1999: 55; Gantenbein et al., 2000: 858 (in part); Fet & Braunwalder, 2005: 28.

Euscorpius germanus: Komposch & Scherabon, 1999: 621; Komposch et al., 2001: 267; Soleglad & Sissom, 2001: 48; Kofler, 2002: 137; Fet et al., 2004: 55 (in part); Komposch, 2004: 444; Vignoli & Salomone, 2008: 205 (in part); Komposch, 2009: 359; Fet, 2010: 6 (in part); Tropea et al., 2015: 3; Fet et al., 2016: 6.

Euscorpius (Euscorpius) germanus: Fet & Sissom, 2000: 366–368 (in part; complete references list until 1998).

Euscorpius (Euscorpius) germanus germanus: Fet & Sissom, 2000: 366–368 (in part).

Euscorpius (Euscorpius) germanus marcuzzii: Fet & Sissom, 2000: 368 (in part).

Euscorpius marcuzzii: Mancini, 2018: 17.

Euscorpius (Alpiscorpius) germanus Karyotypic race I (Ege 46a): Štundlová et al., 2019: 156.

= *Euscorpius germanus marcuzzii* Valle et al., 1971: 96, syn. n. <http://zoobank.org/urn:lsid:zoobank.org:act:86E73B4F-7774-4795-970D-95E27DBD9D50>

TYPE LOCALITY AND TYPE DEPOSITORY. **Italy**, *South Tyrol*: Brixen (=Bressanone); neotype ♂ designated by Gantenbein et al. (2000: 858), NMBS, No. BG-109-07.

MATERIAL EXAMINED (NMPC): 29♂12♀. **Austria**, *Carinthia*: Nassfeld Pass, 46.560°N 13.278°E, 2♂ (Nos. S045, S046); Walchenbach, 47.273°N 10.782°E, 3♂ (Nos. S425, S468, S527) 1♂. **Italy**, *Friuli-Venetia Giulia*: Gerchia, 46.247°N 12.883°E, 3♂ (Nos. S083, S086, S087); Lestans, 46.165°N 12.880°E, 2♂ (Nos. S082, S088); *South Tyrol*: Montechiaro, 46.632°N 10.564°E, 3♂ (Nos. S185, S263, S274); Schluderns, 46.669°N 10.593°E, 2♂ (Nos. S254, S264) 1♂; *Trentino*: Ometto, 45.753°N 11.117°E, 1♂ (No. S283) 1♀; Passo Rolle, 46.293°N 11.771°E, 1♂6♀ (Nos. S1002, S1003, S1004, S1059, S1060, S1061, S1077); Quellenhof, 46.747°N 11.216°E, 4♂ (Nos. S444, S432, S437, S445) 2♂4♀; *Veneto*: Peaio, 46.414°N 12.277°E, 1♂ (No. S847); Soffranco, 46.280°N 12.244°E, 3♂2♀ (Nos. S184, S1006, S1008, S1010, S1011).

DIAGNOSIS. We limit *Alpiscorpius germanus* (C. L. Koch, 1837) to the “Karyotypic race I (Ege 46a)” defined by Štundlová et al. (2019), which has $2n = 46$ chromosomes. The karyotype is composed of 36 metacentric and 10 submetacentric chromosomes (fig. S1D in Štundlová et al., 2019). The rDNA clusters are situated in the subterminal region of the long arms of the metacentric chromosome pair 11 (fig. S1D in Štundlová et al., 2019). Number of pectinal teeth (Dp) in male usually 8 (ca. 60% of examined specimens). Number of patellar ventral trichobothria (Pv) 5. Reduction of patellar external trichobothria from 4 to 3 common in series *et* (>10%) and very common in series *eb_a* (up to 25%); see also Notes.

VARIABILITY. We scored standard phenotypic markers for 26 examined specimens (24♂, 2♀), with the following variation observed:

Dp in males (n=24): 8/3 (1), 6/6 (1), 7/7 (3), 7/8 (1), 8/8 (11), 8/9 (1), 9/8 (3), 9/9 (3); in total (not counting one aberrant *Dp*=3) 6 in 4.26% (2); 7 in 14.89% (7), 8 in 59.57% (28), and 9 in 21.28% (10); mean = 7.98, SD = 0.74.

Dp in females (n=2): 6/6 (1), 8/8 (1).

Pv (n=26): 5/3 (1), 5/5 (25); in total (not counting one aberrant *Pv*=3) 5 in 100% (51); mean = 5.00, SD = 0.0.

et (n=26): 3/3 (2), 3/4 (1), 4/3 (2), 4/4 (20), 4/5 (1); in total, 3 in 10.87% (13.46%), 4 in 84.62% (18), and 5 in 1.92% (1); mean = 3.89, SD = 0.38.

eb_a (n=26): 3/3 (3), 3/4 (4), 4/3 (3), 4/4 (16); in total, 3 in 25% (13) and 4 in 75% (39); mean = 3.75, SD = 0.43.

DISTRIBUTION. Austria, Italy (east of the Adige River: Friuli-Venetia Giulia, South Tyrol, Trentino, Veneto), Switzerland (Grisons: Val Müstair) (Fig. 71). *A. germanus* is the northernmost species of the genus *Alpiscorpius*.

NOTES. Populations of *A. germanus* from Italy were studied by Bonacina (1980) and Gantenbein et al. (2000). Gantenbein et al. (2000) published 16S mtDNA sequences for 11 populations of “*Euscorpius (Alpiscorpius) germanus*” (Switzerland: *Grisons*: Santa Maria, now Val Müstair); Italy: *South Tyrol*: Schluderns, Völs; *Trentino*: Vetriolo, Mezzocanale, *Veneto*: Borca di Cadore; Austria: Starkenbach, Tarrenz, Kranzach, Dellach, Oberdrauburg), all of which closely match DNA sequences of Ege 46a (= *A. germanus*) obtained independently by Štundlová et al. (2019). Since *A. germanus* is restricted in our study, the Italian populations studied by Bonacina (1980) should be reassessed, and their phenotypic markers scored from the material deposited in MCSNB.

Graham et al. (2012: 42) published a *CoxI* mtDNA sequence for a population of “*Euscorpius (Alpiscorpius) germanus*” from Egna (Neumarkt) (Italy, Trentino), collected by F. Šťáhlavský, which closely matches those of Ege 46a (= *A. germanus*) obtained independently by Štundlová et al. (2019).

Note that *A. germanus* (C. L. Koch, 1837) *s. str.* is not found in Slovenia; instead, populations from Slovenia formerly listed under “*Euscorpius germanus*” are described below as two new species, *A. kappa* sp. n. (Slovenia) and *A. lambda* sp. n. (Slovenia, Italy).

Scherabon (1984, 1987) scored the standard phenotypic markers for a large series (over 200 specimens) of this species in Austria (as “T-Form” of *Euscorpius germanus*), with the following results (recalculated here; *et* and *eb_a* data from Scherabon, 1984):

Dp in males (n=74): 7/7 (2), 7/8 (4), 8/7 (8), 8/8 (45), 8/9 (3), 9/8 (5), 9/9 (6), 10/10 (1); in total, 7 in 10.81% (16), 8 in 74.32% (110), 9 in 13.51% (20), and 10 in 1.35% (2); mean = 8.08, SD = 0.65.

Dp in females (n=158): 4/6 (1), 6/4 (1), 5/5 (9), 5/6 (11), 6/5 (7), 6/6 (91), 6/7 (14), 7/6 (5), 7/7 (18), 8/7 (1); in total, 4 in 0.63% (2), 5 in 11.39% (36), 6 in 69.94% (221), 7 in 17.72% (56), and 8 in 0.32% (1); mean = 6.06, SD = 0.57.

Pv (n=238): 3/5 (1), 4/4 (2), 4/5 (7), 5/4 (6), 5/5 (211), 5/6 (3), 6/5 (7), 6/6 (1); in total, 3 in 0.21% (1), 4 in 3.57% (17), 5 in 93.70% (446), and 6 in 2.52% (12); mean = 4.99, SD = 0.26.

et (n=238): 3/4 (13), 4/3 (5), 4/4 (213) 4/5 (3), 5/4 (4); in total, 3 in 7.56% (18), 4 in 89.50% (213), and 5 in 2.94% (7); mean = 3.98, SD = 0.23.

eb_a (n=238): 0/4 (1), 2/3 (1), 4/2 (1), 3/3 (5), 3/4 (15), 4/3 (8), 4/4 (206), 5/4 (1); in total (not counting one aberrant), 2 in 0.42% (2), 3 in 7.37% (34), 4 in 92.0% (437), and 5 in 0.21% (1); mean = 3.91, SD = 0.34.

The reduction from 4 to 3 in both *et* group (7.56%) and *eb_a* group (7.37%) in the marginal Austrian populations appears to be less than in examined Italian populations.

Štundlová et al. (2019) have not studied the karyotypes of the Swiss population from Grisons (Santa Maria, now Val

Müstair; see Braunwalder, 2001; Fet & Braunwalder, 2005) but the 16S mtDNA data (Gantenbein et al., 2000) confirms that they belong to *A. germanus* (C. L. Koch, 1837) *sensu stricto*, as defined in this study. Fet & Braunwalder (2005) scored the standard phenotypic markers for 46 specimens of the Val Müstair population, with the following results:

Dp in males (n=12): 8.32, SD= 0.53.

Dp in females (n=25): mean = 6.46, SD = 0.63.

Pv (n=44): mean=4.92, SD= 0.27.

et (n=44): 3 in 6.82% (6) and 4 in 93.18% (82); mean = 3.94, SD = 0.93.

A great stability of *Pv*=5 within this species in all studied populations is notable compared to *Pv*=6 in *A. alpha* and a bimodal distribution of this trait (5 to 6) in *A. beta*. The reduction from 4 to 3 in *et* group (6.82%) in the marginal Swiss population is slightly less than in examined Italian populations.

A special discussion is needed of the enigmatic taxon *Euscorpius germanus marcuzzii* Valle et al., 1971. It was first recorded by Marcuzzi & Fabris (1957) from the Dolomites (northeastern Italy) as a population with 20 trichobothria (as opposed to common 21) on the external aspect of the pedipalp patella. Valle et al. (1971: 95-96) very briefly (in just one line) described and named a new subspecies from the “refugial massifs of limestone Venetian Pre-Alps (Italy) and northern Slovenia”, without designating type specimens or exact locality (a large series exists in MCSNB that could be considered as syntypes). The *sole* morphological character originally distinguishing this taxon from *E. g. germanus* was the existence of 3 trichobothria instead of 4 in the accessory basal group ($eb_a = 3$) on the external aspect of pedipalp.

Recently, Mancini (2018) elevated *E. g. marcuzzii* to species level (without any justification) and designated the male lectotype from Bassano del Grappa (Vicenza, Veneto, Italy, 45.7667°N 11.7333°E, 1959, leg. R. Bianchi, MCSNB 333; paralectotypes 1♂ 2♀, same label, MCSNB 328, 330, 332), in the Venetian Pre-Alps (*Ital.* ‘Prealpi Venete’). Mancini also listed three paralectotypes from the same locality, thus limiting the type series to the type locality. Bassano del Grappa, which lies east of Adige River, is close to the range of *A. germanus* populations analyzed by Štundlová et al. (2019, fig. 1), e.g. Ometto (45.753°N 11.117°E). Therefore, *Euscorpius germanus marcuzzii* Valle et al., 1971, is a synonym of *Alpiscorpius germanus* (C. L. Koch, 1837), **syn. n.**, *sensu stricto*.

Bonacina (1980) mentioned a number of populations from northeastern Italy (Goriziano area) and Slovenia, some as “pure” *E. g. marcuzzii*, and some “mixed with *E. g. germanus*” (as well as “hybrid”, i.e. asymmetric $eb_a = 3/4$ or $4/3$ in the same individual!). Gantenbein et al. (2000) treated *E. g. marcuzzii* as a dubious taxon. Their DNA analysis of *E. germanus* from Italy in fact included asymmetrical specimens ($eb_a = 3/4$ or $4/3$) which were found to be rare at Bezzecca (only one find) but were much more common at Auronzo di Cadore, Belluno, Schluderns, Voltago, Vetriolo, and Völs. None of the populations mentioned corresponded to a monophyletic, clearly divergent clade.

At the same time, the Slovenian specimens of “*E. germanus*” studied by Gantenbein et al. (2000) (Črniče) did form a separate DNA clade; this population had both $eb_a = 3$ and $eb_a = 4$ specimens. The 16S rRNA DNA data for this population matches that for our *A. lambda* sp. n.; see below for discussion of its variability.

Moreover, the same reduction has been detected in the “*mingrelicus* complex” of this genus. While it is rare in the Anatolian-Caucasian part of the range (Tropea et al., 2015), our data on newly described species of the “*gamma* group” in Slovenia (see below) indicate that it is common at least in some species (*A. omikron* sp. n.); see below.

Thus, $eb_a = 3$ reduction represents a local phenotypic variation in some (but not all) species of *Alpiscorpius*, and is more or less prevalent in certain geographic areas. It could provide a useful marker for microevolutionary studies at population level; the existence of fluctuating asymmetry suggests incomplete dominance/penetrance of this phenotype (see Discussion)

Alpiscorpius kappa sp. n.

(Figures 33–37, 71, Tables 1, 2, 5)

<http://zoobank.org/urn:lsid:zoobank.org:act:6E655A9B-6348-425E-8014-1BF0F166AD03>

Euscorpius germanus: Fet et al., 2001: 264 (in part?).

Euscorpius (Alpiscorpius) germanus Karyotypic race III (Ege 46c): Štundlová et al., 2019: 156.

TYPE LOCALITY AND TYPE DEPOSITORY. **Slovenia**: *Gorenjska*, Njmski Rovt, 46.275°N 13.992°E; NMPC.

TYPE MATERIAL (NMPC): 6♂. **Slovenia**, *Gorenjska*: Bohinjska Bistrica, 46.279°N 13.962°E, 1♂ (paratype No. S017); Njmski Rovt, 46.275°N 13.992°E, 4♂ (holotype No. S683, paratypes Nos. S695, S709, S712); *Goriška*: Roče, 46.108°N 13.817°E, 1♂ (paratype No. S280).

ETYMOLOGY. Di Caporiacco (1950) named three subspecies of *Euscorpius germanus* after the letters of the Greek alphabet *alpha*, *beta*, and *gamma*. We continue in this style for another cryptic species and name it *kappa* after Greek “κάρπα”.

DIAGNOSIS. *Alpiscorpius kappa* sp. n. is a cryptic species of the “*germanus* group” of the “*germanus* complex”, defined by Štundlová et al. (2019) as “Karyotypic race III (Ege 46c)” which has $2n = 46$ chromosomes. The karyotype is composed of 42 metacentric and 4 submetacentric chromosomes (fig. S1F in Štundlová et al., 2019). The rDNA clusters are located in the terminal region of the long arms of the metacentric chromosome pair 14 (fig. 2E and fig. S1F in Štundlová et al., 2019). Number of pectinal teeth (*Dp*) in male usually 7 (70% of examined specimens). Number of patellar ventral trichobothria (*Pv*) usually 5. Reduction of patellar external trichobothria from 4 to 3 present common in group eb_a (20%); no reduction in group *et*.



Figures 23–32: *Alpiscorpius kappa* sp. n., male holotype (23–27, No. S683) and *A. lambda* sp. n., male holotype (28–32, No. S791). **Figures 23–25, 28–30.** Pedipalp chela and patella dorsal (23, 28), external (24, 29), and ventral (25, 30) views. **Figures 26–27, 31–32.** Metasoma III–V and telson, ventral (26, 31), and lateral (27, 32) views.

DESCRIPTION OF THE MALE HOLOTYPE. The following description is based primarily on the holotype male. Measurements of the holotype are presented in Table 1. Carapace, tergites, and pedipalps reddish-brown; carapace with some darker mottling; metasoma dark reddish-brown with dark mottling; telson, legs, and sternites dark yellow to reddish-brown; chelicerae light, slightly reticulated. Anterior edge of carapace essentially straight; smooth and lustrous, lacking any indication of carinae. There are two lateral eyes. Median eyes and tubercle are small in size. Tergites I–VII essentially smooth; tergite VII lacking lateral and median carinal pairs. Sternites III–VII smooth and lustrous; VII lacking lateral and median carinae. Stigmata are small, narrow elliptical. Metasomal segment V smooth without granulation and carinae. Vesicle of telson swollen and elongated, with short highly curved aculeus. Vesicle essentially void of granules, lustrous. Pectinal teeth number 8/7. Pedipalp carinae well-developed (Figs. 33–35). Movable fingers bear 7 rows of denticles with external and internal denticles. Trichobothrial patterns type C, neobothriotaxic: chela ventral = 4/4; patellar $eb = 4/4$, $eb_a = 4/4$, $esb = 2/2$, $em = 3/3$, $est = 3/3$, $et = 5/5$; patellar ventral = 6/6. Tarsus of legs with single row of spinules on ventral surface.

VARIABILITY. We scored standard phenotypic markers for 5 type specimens (all ♂), with the following variation observed: *Dp* in males (n=5): 7/7 (2), 7/8 (2), 8/7 (1); in total (n=20), 7 in 70% (7), and 8 in 30% (3); mean = 7.30, SD = 0.48.

Pv (n=5): 5/6 (1), 5/5 (9); in total, 5 in 90% (9) and 6 in 10% (1); mean = 5.10, SD = 0.32.

et (n=5): 4/4 (10); in total, 4 in 100% (10).

eb_a (n=5): 4/3 (2), 4/4 (3); in total, 3 in 20% (2) and 4 in 80% (8); mean = 3.80, SD = 0.42.

DISTRIBUTION. Slovenia (Gorenjska, Goriška) (Fig. 71).

NOTES. Slovenian populations of “*Euscorpius germanus*” (found only in the western part of Slovenia) listed by Fet et al. (2001) could refer to both *A. kappa* sp. n. and *A. lambda* sp. n. The former, however, appears to have a more restricted range in western Slovenia and is currently known only from two localities. In Gorenjska region, *A. kappa* sp. n. is sympatric with *A. omikron* sp. n. (“*gamma* group”, see below).

***Alpiscorpius lambda* sp. n.**

(Figures 28–32, 53–58, 71, Tables 1, 2, 5)

<http://zoobank.org/urn:lsid:zoobank.org:act:7E8284DD-5574-4A6C-AA9C-87566FB93106>

Euscorpius germanus marcuzzii: Valle et al., 1971: 96 (in part; Slovenia); Bonacina, 1980: 70 (in part; Slovenia); Fet & Sissom, 2000: 368 (in part; Slovenia); Fet, 2010: 6.

Euscorpius germanus: Gantenbein et al., 2000: 845 (in part; Slovenia: Črniče); Scherabon et al., 2000: 255 (in part; Slovenia: Črniče); Fet et al., 2001: 264 (in part); Graham et al., 2012: 42 (in part; Slovenia: Trnovo ob Soči).

Euscorpius (Alpiscorpius) germanus Karyotypic race II (Ege 46b): Štundlová et al., 2019: 156.

TYPE LOCALITY AND TYPE DEPOSITORY. **Slovenia**: Goriška, Kamno, 46.215°N 13.639°E; NMPC.

TYPE MATERIAL (NMPC): 12♂9♀. **Slovenia**: Goriška, Kamno, 46.215°N 13.639°E, 2♂ (holotype No. S791, paratype No. S792) 1♀ (paratype); Občina Kobarid I, 46.251°N 13.585°E, 2♂ (paratypes Nos. S787, S788); Občina Kobarid II, 46.249°N 13.587°E, 2♂ (paratypes Nos. S789, S790); Srpenica, 46.295°N 13.495°E, 2♂ (paratypes Nos. S265, S278) 4♀ (paratypes); Trdnjava Kluže, 46.362°N 13.589°E, 1♂ (paratype No. S266) 2♀ (paratypes). *Notranjska*, Veliko Ubeljisko, 45.775°N 14.069°E, 1♂2♀ (paratypes Nos. S703, S784, S815); Laze I, 45.860°N 14.270°E, 1♂ (paratype No. S692); Laze II, 45.867°N 14.259°E, 1♂ (paratype No. S785).

ETYMOLOGY. Di Caporiacco (1950) named three subspecies of *Euscorpius germanus* after the letters of the Greek alphabet *alpha*, *beta*, and *gamma*. We continue in this style for another cryptic species and name it *lambda* after Greek “*λάμβδα*”.

DIAGNOSIS. *Alpiscorpius lambda* sp. n. is a cryptic species of the “*germanus* group” of the “*germanus* complex”, defined by Štundlová et al. (2019) as “Karyotypic race II (Ege 46b)” which has 2n = 46 chromosomes. The karyotype is composed of 34 metacentric and 12 submetacentric chromosomes (fig. S1D in Štundlová et al., 2019). The rDNA clusters are located in the subterminal region of the long arms of the metacentric chromosome pair 11 (fig. 2D and fig. S1E in Štundlová et al., 2019). Number of pectinal teeth (*Dp*) in male usually 7 to 8. Number of patellar ventral trichobothria (*Pv*) usually 5. Reduction of patellar external trichobothria from 4 to 3 present dominant in group eb_a (>70% in type series) (see Figs. 53–58). No reduction in group *et*.

DESCRIPTION OF THE MALE HOLOTYPE. The following description is based primarily on the holotype male. Measurements of the holotype are presented in Table 1. Carapace, tergites, and pedipalps reddish-brown; carapace with some darker mottling; metasoma dark reddish-brown with dark mottling; telson, legs, and sternites dark yellow to reddish-brown; chelicerae light, slightly reticulated. Anterior edge of carapace essentially straight; smooth and lustrous, lacking any indication of carinae. There are two lateral eyes. Median eyes and tubercle are small in size. Tergites I–VII essentially smooth; tergite VII lacking lateral and median carinal pairs. Sternites III–VII smooth and lustrous; VII lacking lateral and median carinae. Stigmata are small, narrow elliptical. Metasomal segment V smooth without granulation and carinae. Vesicle of telson swollen and elongated, with short highly curved aculeus. Vesicle essentially void of granules, lustrous. Pectinal teeth number 7/8. Pedipalp carinae well-developed (Figs. 28–30). Trichobothrial patterns type C, neobothriotaxic: chela ventral = 4/4; patellar $eb = 4/4$, $eb_a = 3/4$ (see below for variability in the type series), $esb = 2/2$, $em = 3/3$, $est = 3/3$, $et = 5/5$; patellar ventral = 5/5. Tarsus of legs with single row of spinules on ventral surface.

VARIABILITY. We scored standard phenotypic markers for 14 type specimens (12♂ 2♀), with the following variation observed:

Dp in males (n=12): 0/7 (1), 2/7 (1), 6/5 (1), 6/6 (3), 7/6 (1), 7/7 (14), 8/7 (1); in total. 6 in 16.67% (4); 7 in 33.33% (8), 8 in 45.83% (11), and 9 in 4.17% (1); mean = 7.38, SD = 0.82.

Dp in females (n=2): 6/5, 6/6.

Pv (n=14): 4/5 (1), 5/5 (13); in total, 4 in 3.57% (1), and 5 in 96.43% (14); mean = 4.96, SD = 0.19.

et (n=14): 4/4 (14); in total, 4 in 100% (28).

eb_a (n=14): 3/?(1), 3/3 (7), 3/4 (1), 4/3 (3), 4/4 (2); in total, 3 in 70.37% (19) and 4 in 29.63% (8); mean = 3.30, SD = 0.47.

DISTRIBUTION. Slovenia (Goriška, Notranjska: Fig. 71), ?Italy.

NOTES. Slovenian populations of “*Euscorpius germanus*” listed by Fet et al. (2001) could refer to both *A. kappa* sp. n. and *A. lambda* sp. n.; the latter appears to have a wider range in western Slovenia and represents the westernmost species of the “*germanus* complex”. This species is likely also found in northeastern Italy (Gorizia; Bonacina, 1980).

Gantenbein et al. (2000) published a 16S mtDNA sequence of a population of “*Euscorpius germanus*” from Črniče (Slovenia: Goriška), which closely matches those of Ege 46b (= *A. lambda* sp. n.) obtained independently by Štundlová et al. (2019).

Graham et al. (2012) published a *CoxI* mtDNA sequence for a population of “*Euscorpius (Alpiscorpius) germanus*” from Trnovo ob Soči (Slovenia, Goriška, Soča Valley), which closely matches those of Ege 46b (= *A. lambda* sp. n.) obtained independently by Štundlová et al. (2019).

Populations of *Alpiscorpius* in Italy are known for the variability of the *eb_a* trichobothrial group which fluctuates between 4 and 3 (see the discussion of *Euscorpius germanus marcuzzii* above). The same variation is also observed in *A. lambda* sp. n., a new Slovenian species of the “*germanus* group”. We scored a sample from the type series of *A. lambda* sp. n. (27 pedipalps; see above), which had *eb_a* = 3 in 19 cases (70.37%), and *eb_a* = 4 in 8 cases (29.63%). We also scored *eb_a* for additional (non-type) 23 specimens from Slovenia (12 from Črniče and 11 from Planinsko Polje). The Črniče population (Goriška region, near Nova Gorica, 45.91°N, 13.77°E) is confirmed via DNA sequence as *A. lambda* sp. n. (see Note 2 above). In Črniče, incidence of *eb_a* = 3 was only 25 %, and it was present only in asymmetric (*eb_a* = 3/4) individuals. Planinsko Polje is the famous karst area in the Notranjska region, which includes Laze, the locality of some of our paratypes. In Planinsko Polje, incidence of *eb_a* = 3 was 90.9 %, and, conversely, *eb_a* = 4 was present only in asymmetric (*eb_a* = 3/4) specimens. Therefore, both this phenotypic trait and its asymmetric expression exhibit high intraspecific variation. This pattern of phenotypic variation (which appears to be an ancestral polymorphism in the genus, especially common in the “*germanus* complex”) was already well-documented by Bonacina (1980) who scored as many as 320 specimens

from Slovenia (possibly *A. lambda* sp. n. and *A. kappa* sp. n.). Bonacina (1980) reported *eb_a* = 3 specimens (as *E. g. marcuzzii*) from Cerknica, Polhov Gradec, Trenta, Kobarid, and Laze [both Kobarid and Laze are among our *A. lambda* sp. n. localities]. In Bonacina’s samples, 33% of 21 individuals from Polhov Gradec (46.06°N, 14.31°E) were asymmetric, and were interpreted as “hybrids between *E. g. marcuzzii* and *E. g. germanus*”; see Discussion below on trichobothrial asymmetry and its possible importance as a phenotypic marker.

“*mingrelicus* complex”

DIAGNOSIS: Total length of adults 18–40 mm. Pedipalp chela with 4 trichobothria (*3V*, *Et*) on ventral surface. Patella of pedipalp with 3 external trichobothria in *em* group, 4–5 external trichobothria in *et* group, and 5–6 ventral trichobothria. Pedipalp chela fixed finger with trichobothrium *est* located distinctly closer to *dsb* than to *et*; *et-est/est-dsb* distance ratio is about 2 (Fig. 44). Metasoma V ventrally without carinae, finely to strongly granulated, rarely smooth.

COMPOSITION. We subdivide all valid species of the “*mingrelicus* complex” into informal “*gamma* group” and “*mingrelicus* group” according to their DNA-based phylogeny (Graham et al., 2012; Fet et al., 2016; Štundlová et al., 2019). The karyotypic identity is currently known only for the “*gamma* group” (Štundlová et al., 2019). Geographic distribution of these two groups is disjunct.

SUBORDINATE TAXA (9 SPECIES).

“*gamma* group” (Europe; see Comments):

Alpiscorpius beroni (Fet, 2000), **comb. n.** (Albania)

A. gamma (Di Caporiacco, 1950), **comb. n.** (Slovenia, ?Italy, ?Croatia)

A. omega sp. n. (Slovenia)

A. omikron sp. n. (Slovenia)

A. sigma sp. n. (Italy, Slovenia)

A. ypsilon sp. n. (Austria, Slovenia)

“*mingrelicus* group” (Anatolia and Caucasus):

A. mingrelicus (Kessler, 1874), **comb. n.** (Georgia, Russia, Turkey)

A. phrygius (Bonacina, 1980), **comb. n.** (Turkey)

A. uludagensis (Lacroix, 1995), **comb. n.** (Turkey)

COMMENTS. Including new taxa described in this paper, the “*mingrelicus* complex” includes 9 species inhabiting the large region from the Eastern Alps (Austria, Italy, Slovenia), the Balkan Peninsula, Anatolia, and the Caucasus Mts. (Turkey, Georgia, Russia). The Anatolian-Caucasian taxa of this complex were recently revised (Tropea et al., 2015); in this revision, *Alpiscorpius mingrelicus* (Kessler, 1874) was limited to Anatolia and Caucasus.

At the same time, the widespread *Alpiscorpius* spp. from the Balkans (Bosnia & Herzegovina, Bulgaria, Croatia,

Kosovo, Montenegro, North Macedonia, Serbia), formerly listed under *Euscorpius gamma* or *E. mingrelicus* (Bonacina, 1980; Fet & Sissom, 2000; Graham et al., 2012), currently remain unrevised and unassigned. Available names, potentially applicable to some of these populations, are: *Scorpius bosnensis* von Möllendorff, 1873; *Euscorpius germanus dinaricus* Di Caporiacco, 1950; *E. germanus histororum* Di Caporiacco, 1950; and *E. mingrelicus caporiaccoi* Bonacina, 1980 (Fet & Sissom, 2000). See also discussion below on *E. germanus mesotrichus* Hadži, 1929.

From the “*mingrelicus* complex”, Štundlová et al. (2019) analyzed 23 Alpine populations which represent four new, cryptic species of the “*gamma* group”, different from *A. gamma* (Di Caporiacco, 1950) **comb. n.**

“*gamma* group”

Alpiscorpius gamma (Di Caporiacco, 1950), **comb. n.**
(Table 1)

<http://zoobank.org/urn:lsid:zoobank.org:act:BFD7E5B7-981B-48DC-8827-559563CE14B4>

?*Euscorpius germanus* “forma C”: Capra, 1939: 204 (part: Tarnova della Selva; now Slovenia, Trnovo).

Euscorpius germanus gamma Di Caporiacco, 1950: 214.

Euscorpius mingrelicus gamma: Fet & Sissom, 2000: 370.

Euscorpius gamma: Scherabon et al., 2000: 253 (Slovenia, in part); Fet et al., 2001: 264 (Slovenia, in part); Fet et al., 2004: 55 (Slovenia, in part).

=*Euscorpius mingrelicus caprai* Bonacina, 1980: 73–75 (see Fet & Sissom, 2000: 370). <http://zoobank.org/urn:lsid:zoobank.org:act:F39631A9-A5E3-4B71-9D26-7C85808D084F>

TYPE LOCALITY AND TYPE DEPOSITORY. **Slovenia**, *Goriška*: north Istria, mouth of the Rižana (Risano) River; MZUF.

TYPE MATERIAL. Lectotype ♀ (designated by Scherabon et al., 2000: 259) (MZUF 5581), **Slovenia**: *Goriška*, north Istria, mouth of the Rižana River. Paralectotypes (11 specimens, MZUF): **Slovenia** (mouth of the Rižana River, Kamno, Vrsno, Krn, Trenta Valley, and Panovizza, now Panovec), **Italy** (Udine: Cave di Predil), and unspecified localities in Soča (Isonzo) River Valley in Slovenia [possibly *A. sigma* sp. n.].

DISTRIBUTION. Slovenia (*Goriška*); ?Italy, ?Croatia.

NOTES. The karyotypic data for this species have not been published by Štundlová et al. (2019). Currently, we restrict *Alpiscorpius gamma* (Di Caporiacco) only to its type locality in southwestern Slovenia, close to the Croatian border. According to our unpublished data, populations from this area has $2n = 78$; it is difficult at this moment to further characterize *A. gamma* s. str. due to the lack of material. The paralectotype series likely includes members of other cryptic species; the specimens reported from NE Italy (Udine; see also Vignoli

& Salomone, 2008, fig. 27) possibly refer to *A. sigma* sp. n. (so far the only confirmed “*gamma* group” species in Italy; its holotype originates from Studena Bassa in Udine). The same may be true for a population from Tarnova della Selva (now Slovenia, Trnovo) mentioned by Capra (1939) and Bonacina (1980).

Fet et al. (2001) listed numerous Slovenian populations of “*Euscorpius gamma*” and noted their “patchy distribution” across the complex mountainous landscapes. These records, as we see now, could refer to *at least five* cryptic, allopatric species of the “*gamma* group”, four of which are described below.

In the western part of Slovenia, *Alpiscorpius* species of the “*gamma* group” (probably *A. omikron* sp. n.) were found to be sympatric or maybe even syntopic with species of the “*germanus* group” (*A. kappa* sp. n. and *A. lambda* sp. n.).

Alpiscorpius omega sp. n.

(Figures 33–37, 59–64, 71, Tables 1, 3, 5)

<http://zoobank.org/urn:lsid:zoobank.org:act:94950DBF-658C-46B8-A944-06C178BAAECE>

?*Euscorpius gamma*: Fet et al., 2001: 264 (Slovenia, in part).
Euscorpius (Alpiscorpius) gamma Karyotypic race IV (Ega 88): Štundlová et al., 2019: 157.

TYPE LOCALITY AND TYPE DEPOSITORY. **Slovenia**, *Gorenjska*: Kamnik, 46.201°N 14.602°E; NMPC.

TYPE MATERIAL (NMPC). 21♂6♀. **Slovenia**, *Dolenjska*: Sklendrovec, 46.120°N 15.028°E, 1♂ (paratype No. S742); Podbočje, 45.860°N 15.458°E, 2♂ (paratype No. S743, S800); *Gorenjska*: Kamnik, 46.201°N 14.602°E, 4♂ (holotype No. S259 and paratypes Nos. S258, S416, S436) 3♀ (paratypes); Gradež, 45.880°N 14.616°E, 1♀ (paratype No. S686); Ig, 45.954°N 14.531°E, 1♂ (paratype No. S685); Laško I, 46.157°N 15.231°E, 1♂ (paratype No. S744); Laško II, 46.158°N 15.237°E, 2♂ (paratypes Nos. S745, S751); Kotredež, 46.158°N 14.993°E, 1♂ (paratype No. S741); Štefanja Gora, 46.284°N 14.496°E, 1♂ (paratype No. S694); *Štajerska*: Kebelež, 46.399°N 15.447°E, 3♂ (paratypes Nos. S404, S417, S522) 2♀ (paratype); Nova Štifta, 46.270°N 14.768°E, 2♂ (paratypes Nos. S483, S1079); Vologa, 46.262°N 14.895°E, 3♂ (paratypes Nos. S740, S794, S799).

ETYMOLOGY. Di Caporiacco (1950) named three subspecies of *Euscorpius germanus* after the letters of the Greek alphabet *alpha*, *beta*, and *gamma*. We continue in this style for another cryptic species and name it *omega* after Greek “ὦμέγα”.

DIAGNOSIS. *Alpiscorpius omega* sp. n. is a cryptic species of the “*gamma* group” of the “*mingrelicus* complex”, defined by Štundlová et al. (2019) as “Karyotypic race IV (Ega 88)”, which has $2n = 88$ chromosomes. The karyotype

Dimensions (mm)		<i>A. omega</i> sp. n.	<i>A. omikron</i> sp. n.	<i>A. sigma</i> sp. n.	<i>A. ypsilon</i> sp. n.
		♂ holotype	♂ holotype	♂ holotype	♂ holotype
Carapace	L / W	3.345 / 3.305	3.408 / 3.561	3.164 / 2.936	3.489 / 3.316
Mesosoma	L	5.384	8.273	8.052	5.456
Tergite VII	L / W	1.205 / 2.753	1.453 / 2.820	1.268 / 2.740	1.260 / 2.881
Metasoma + telson	L	11.627	12.314	11.783	13.283
Segment I	L / W / D	1.013 / 1.464 / 1.168	1.180 / 1.450 / 1.201	1.080 / 1.318 / 1.206	1.304 / 1.548 / 1.435
Segment II	L / W / D	1.191 / 1.293 / 1.109	1.274 / 1.359 / 1.153	1.269 / 1.249 / 1.086	1.378 / 1.398 / 1.332
Segment III	L / W / D	1.519 / 1.246 / 1.068	1.490 / 1.288 / 1.056	1.427 / 1.206 / 1.096	1.553 / 1.380 / 1.202
Segment IV	L / W / D	1.752 / 1.205 / 1.108	1.773 / 1.239 / 1.106	1.717 / 1.097 / 1.053	1.822 / 1.238 / 1.109
Segment V	L / W / D	2.622 / 1.302 / 1.133	3.054 / 1.364 / 1.095	2.886 / 1.304 / 1.073	3.451 / 1.342 / 1.210
Telson	L / W / D	3.520 / 1.550 / 1.423	3.543 / 1.780 / 1.369	3.404 / 1.596 / 1.273	3.775 / 1.610 / 1.461
Pedipalp	L	10.836	10.614	9.913	10.937
Femur	L / W	2.553 / 1.053	2.537 / 1.016	2.383 / 0.943	2.622 / 1.078
Patella	L / W	2.874 / 1.156	2.681 / 1.093	2.570 / 1.051	2.864 / 1.269
Chela	L	5.409	5.396	4.960	5.451
Manus	W / D	1.995 / 1.675	2.012 / 1.956	1.795 / 1.542	2.175 / 2.068
Movable finger	L	2.639	3.645	3.212	3.008
Total	L	20.346	23.995	22.999	22.228

Table 3. Comparative measurements of *Alpiscorpius omega* sp. n., *A. omikron* sp. n., *A. sigma* sp. n., and *A. ypsilon* sp. n. male holotypes. Abbreviations: length (L), width (W, in carapace it corresponds to posterior width), depth (D).

is composed of 20 metacentric, 2 submetacentric, 6 subtelocentric, and 60 telocentric chromosomes (fig. S2E in Štundlová et al., 2019). Polymorphism for chromosomal fusion/fission is present in three specimens from different localities. Their karyotypes are: $2n = 87$ (heterozygous for fusion, 42 bivalents and one trivalent, fig. S3G in Štundlová et al., 2019) and $2n = 89$ (heterozygous for fission, 43 bivalents and one trivalent, fig. S3D in Štundlová et al., 2019). The rDNA clusters are located in the subterminal region of the long arms of the telocentric chromosome pair 27 (fig. 2I and fig. S2E in Štundlová et al., 2019). Number of pectinal teeth (Dp) in male usually 8 (>75% of examined specimens). Number of patellar ventral trichobothria (Pv) 5 (ca. 90%). Reduction of patellar external trichobothria from 4 to 3 common in group *et* (25%) (see Figs. 59–64). There is no $eb_a=4$ reduction.

DESCRIPTION OF THE MALE HOLOTYPE. The following description is based primarily on the holotype male. Measurements of the holotype are presented in Table 2. Carapace, tergites, and pedipalps reddish-brown; carapace with some darker mottling; metasoma dark reddish-brown with dark mottling; telson, legs, and sternites dark yellow to reddish-brown; chelicerae light, slightly reticulated. Anterior edge of carapace essentially straight; smooth and lustrous, lacking any indication of carinae. There are two lateral eyes. Median eyes and tubercle are small in size. Tergites I–VII essentially smooth; tergite VII lacking lateral and median carinal pairs. Sternites III–VII smooth and lustrous; VII lacking lateral and median carinae. Stigmata

are small, narrow elliptical. Metasomal segment V very finely granulated and without lateral carinae. Vesicle of telson swollen and elongated, with short highly curved aculeus. Vesicle essentially void of granules. Pectinal teeth number 8/8. Pedipalps carinae well-developed (Figs. 33–35). Movable fingers bear 7 rows of denticles with external and internal denticles. Trichobothrial pattern type C, neobothriotaxic: chela ventral = 4/4; patellar $eb = 4/4$, $eb_a = 4/4$, $esb = 2/2$, $em = 3/3$, $est = 3/3$, $et = 5/5$; patellar ventral = 5/5. Both pedal spurs present on all legs; tibial spurs absent. Tarsus of legs with single row of spinules on ventral surface.

VARIABILITY. We scored standard phenotypic markers for 22 type specimens (21♂1♀), with the following variation observed:

Dp in males (n=21): 7/7 (2), 7/8 (3), 8/8 (13), 8/9 (3); in total, 7 in 16.67% (7); 8 in 76.19% (32), and 9 in 7.14% (3); mean = 7.90, SD = 0.48.

Dp in females (n=1): 6/6.

Pv (n=22): 4/5 (1), 5/4 (4), 5/5 (17); in total, 4 in 11.36% (5), and 5 in 88.63% (39); mean = 4.89, SD = 0.32.

et (n=22): 0/3 (1), 3/3 (1), 3/4 (2), 4/3 (6), 4/4 (12); in total (n=43, not counting one aberrant pectine), 3 in 25.58% (11) and 4 in 76.74% (32); mean = 3.74, SD = 0.44.

eb_a (n=22): all 4/4.

DISTRIBUTION. Slovenia (Dolenjska, Gorenjska, Štajerska) (Fig. 71).



Alpiscorpius omega sp. n.



Alpiscorpius omikron sp. n.

Figures 33–42: *Alpiscorpius omega* sp. n., male holotype (33–37, No. S259) and *A. omikron* sp. n., male holotype (38–42, No. S103). Figures 33–35, 38–40. Pedipalp chela and patella dorsal (33, 38), external (34, 39), and ventral (35, 40) views. Figures 36–37, 41–42. Metasoma III–V and telson, ventral (36, 41), and lateral (37, 42) views.

Alpiscorpius omikron sp. n.

(Figures 38–42, 65–71, Tables 1, 3, 5)

<http://zoobank.org/urn:lsid:zoobank.org:act:CCFC65C7-0B9A-4C10-A0E8-7B30B808C6FD>*?Euscorpius gamma*: Fet et al., 2001: 264 (Slovenia, in part).*Euscorpius gamma*: Graham et al., 2012: 43 (Slovenia, Bohinj, 46°16'N, 13° 57'E).*Euscorpius (Alpiscorpius) gamma* Karyotypic race II (Ega 58): Štundlová et al., 2019: 156.TYPE LOCALITY AND TYPE DEPOSITORY. **Slovenia**, *Gorenjska*: Polje, 46.270°N 13.907°E; NMPC.TYPE MATERIAL (NMPC): 9♂1♀. **Slovenia**, *Gorenjska*: Bohinjska Bistrica, 46.279°N 13.962°E, 1♂ (paratype No. S398); Nomenj I, 46.272°N 14.033°E, 1♀ (paratype No. S696); Nomenj II, 46.283°N 14.042°E, 1♂ (paratype No. S697); Polje, 46.270°N 13.907°E, 3♂ (holotype No. S103 and paratypes Nos. S020, S119). *Osrednja Slovenija*: Lesno Brdo, 46.011°N 14.321°E, 4♂ (paratypes Nos. S693, S704, S705, S706).ETYMOLOGY. Di Caporiacco (1950) named three subspecies of *Euscorpius germanus* after the letters of the Greek alphabet *alpha*, *beta*, and *gamma*. We continue in this style for another cryptic species and name it *omikron* after Greek “ὀμικρόν”.DIAGNOSIS. *Alpiscorpius omikron* sp. n. is a cryptic species of the “*gamma* group” of the “*mingrelicus* complex”, defined by Štundlová et al. (2019) as “Karyotypic race II (Ega 58)” which has 2n = 58 chromosomes. The karyotype is composed of 42 metacentric, 10 submetacentric and 4 telocentric chromosomes (fig. S2B in Štundlová et al., 2019). The rDNA clusters are located in the subterminal region of the short arms of the metacentric chromosome pair 6 (fig. 2F and fig. S2B in Štundlová et al., 2019). Number of pectinal teeth (Dp) in male usually 8 (63% of examined specimens), more rarely 7. Number of patellar ventral trichobothria (Pv) usually 6 (72%). Reduction of patellar external trichobothria from 4 to 3 very common in both group *et* (ca. 30%) and *eb_a* (ca. 30%) (see Figs. 65–70).

DESCRIPTION OF THE MALE HOLOTYPE. The following description is based primarily on the holotype male. Measurements of the holotype are presented in Table 2. Carapace, tergites, and pedipalps reddish-brown; carapace with some darker mottling; metasoma dark reddish-brown with dark mottling; telson, legs, and sternites dark yellow to reddish-brown; chelicerae light, slightly reticulated. Anterior edge of carapace essentially straight; smooth and lustrous, lacking any indication of carinae. There are two lateral eyes. Median eyes and tubercle are small in size. Tergites I–VII essentially smooth; tergite VII lacking lateral and median carinal pairs. Sternites III–VII smooth and lustrous; VII lacking lateral and median carinae. Stigmata are small, narrow elliptical. Metasomal segment V almost smooth

to very finely granulated and without carinae. Vesicle of telson swollen and elongated, with short highly curved aculeus. Vesicle essentially void of granules. Pectinal teeth number 8/8. Pedipalp carinae well-developed (Figs. 38–40). Movable fingers bear 7 rows of denticles with external and internal denticles. Trichobothrial pattern type C, neobothriotaxic: chela ventral = 4/4; patellar *eb* = 4/4, *eb_a* = 4/4, *esb* = 2/2, *em* = 3/3, *est* = 3/3, *et* = 4/4; patellar ventral = 6/6. Tarsus of legs with single row of spinules on ventral surface.

VARIABILITY. We scored standard phenotypic markers for 9 type specimens (8♂1♀), with the following variation observed:

Dp in males (n=8): 7/7 (1), 8/7 (1), 8/8 (4), 8/9 (1), 9/9 (1); in total, 7 in 18.75% (3), 8 in 62.50% (10), and 9 in 18.75% (3); mean = 8.00, SD = 0.63.*Dp* in females (n=1): 6/6 (1).*Pv* (n=18): 5/5 (2), 6/5 (1), 6/6 (6); in total, 5 in 27.78% (5), 6 in 72.22% (13); mean = 5.72, SD = 0.46.*et* (n=9): 3/4 (5), 4/4 (4); in total, 3 in 27.78% (5) and 4 in 66.67% (39); mean = 3.72, SD = 0.46.*eb_a* (n=9): 4/3 (5), 4/4 (4); in total, 3 in 27.78% (5) and 4 in 66.67% (39); mean = 3.72, SD = 0.46.

DISTRIBUTION. Slovenia (Gorenjska, Osrednja Slovenija) (Fig. 71).

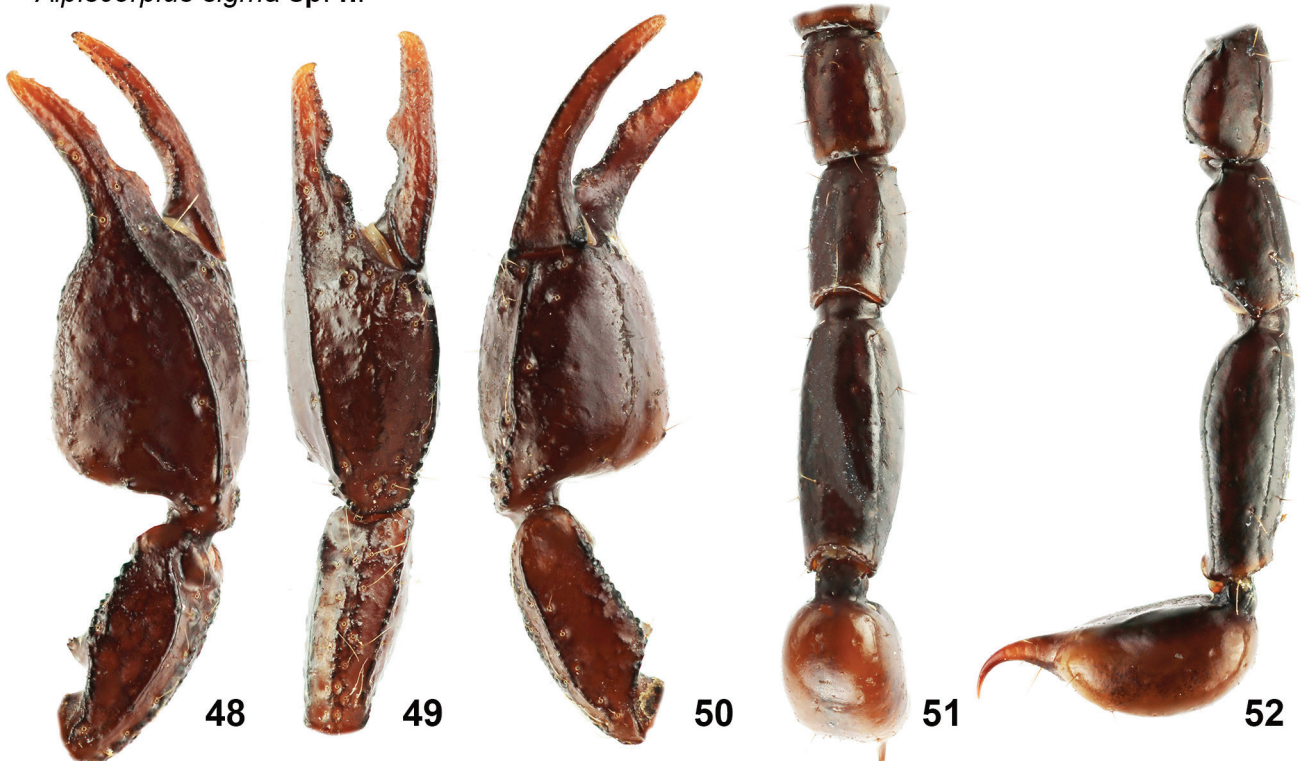
NOTES. *Alpiscorpius omikron* sp. n. is the only so far known “*mingrelicus* complex” species where both *et*=3 and *eb_a*=3 reduction is very common (ca. 30% of scored pedipalps). Interestingly, in the examined series it is only present in asymmetric form (3/4 or 4/3).In Gorenjska region, *A. omikron* sp. n. is sympatric with *A. kappa* sp. n. from the “*germanus* group”.*Alpiscorpius sigma* sp. n.

(Figures 43–47, Tables 1, 3, 5)

<http://zoobank.org/urn:lsid:zoobank.org:act:70536871-F300-4BF9-96B1-885BD05428A5>*?Euscorpius gamma*: Fet et al., 2001: 264 (Slovenia, in part); Vignoli & Salomone, 2008: fig. 27 (Italy: Udine).*Euscorpius (Alpiscorpius) gamma* Karyotypic race II (Ega 60): Štundlová et al., 2019: 156.TYPE LOCALITY AND TYPE DEPOSITORY. **Italy**, *Friuli-Venezia Giulia*: Udine, Studena Bassa, 46.516°N 13.273°E; NMPC.TYPE MATERIAL (NMPC): 2♂. **Italy**, *Friuli-Venezia Giulia*: Udine, Studena Bassa, 46.516°N 13.273°E, 1♂ (holotype No. S044). Paratype: **Slovenia** (extreme northwest), *Gorenjska*: Kranjska Gora, Podkoren, 46.494°N 13.749°E, 1♂ (S018).ETYMOLOGY. Di Caporiacco (1950) named three subspecies of *Euscorpius germanus* after the letters of the Greek alphabet *alpha*, *beta*, and *gamma*. We continue in this style for another cryptic species and name it *sigma* after Greek “σίγμα”.



Alpiscorpium sigma sp. n.



Alpiscorpium ypsilon sp. n.

Figures 43–52: *Alpiscorpium sigma* sp. n., male holotype (43–47, No. S044) and *A. ypsilon* sp. n., male holotype (48–52, No. S739). **Figures 43–45, 48–50.** Pedipalp chela and patella dorsal (43, 48), external (44, 49), and ventral (45, 50) views. The trichobothrial pattern is indicated in Figures 43–45. **Figures 46–47, 51–52.** Metasoma III–V and telson, ventral (46, 51), and lateral (47, 52) views.

DIAGNOSIS. *Alpiscorpius sigma* sp. n. is a cryptic species of the “gamma group” of the “mingrelicus complex”, defined by Štundlová et al. (2019) as “Karyotypic race II (Ega 60)”, which has $2n = 60$ chromosomes. The karyotype is composed of 48 metacentric and 12 submetacentric chromosomes (fig. S2A in Štundlová et al., 2019). In both analysed specimens are 28 bivalents and one quadrivalent chain present in metaphase I. The rDNA clusters are located in the subterminal region of the short arms of the metacentric chromosome pair 6 (fig. S2A in Štundlová et al., 2019). Metasomal segment V very finely granulated and with lateral carinae indicated by several solitary granules. Number of pectinal teeth (Dp) in two examined males is usually 8. Number of patellar ventral trichobothria 6. No $et=3$ or $eb_a=3$ reduction observed in the two known specimens.

DESCRIPTION OF THE MALE HOLOTYPE. The following description is based primarily on the holotype male. Measurements of the holotype are presented in Table 2. Carapace, tergites, and pedipalps reddish-brown; carapace with some darker mottling; metasoma dark reddish-brown with dark mottling; telson, legs, and sternites dark yellow to reddish-brown; chelicerae light, slightly reticulated. Anterior edge of carapace essentially straight; smooth and lustrous, lacking any indication of carinae. There are two lateral eyes. Median eyes and tubercle are small in size. Tergites I–VII essentially smooth; tergite VII lacking lateral and median carinal pairs. Sternites III–VII smooth and lustrous; VII lacking lateral and median carinae. Stigmata are small, narrow elliptical. Metasomal segment V very finely granulated and with lateral carinae indicated by several solitary granules. Vesicle of telson swollen and elongated, with short highly curved aculeus. Vesicle essentially void of granules. Pectinal teeth number 8/8. Pedipalp carinae well-developed (Figs. 43–45). Movable fingers bear 7 rows of denticles with external and internal denticles. Trichobothrial patterns type C, neobothriotaxic: chela ventral = 4/4; patellar $eb = 4/4$, $eb_a = 4/4$, $esb = 2/2$, $em = 3/3$, $est = 3/3$, $et = 4/4$; patellar ventral = 6/6. Tarsus of legs with single row of spinules on ventral surface.

VARIABILITY. We scored standard phenotypic markers for both type specimens (2♂), with the following variation observed: Dp in males (n=2): 8/7 (1), 8/8 (1), in total, 7 in 25% (1), 8 in 75% (3); mean = 7.75, SD = 1.55.

Pv (n=2): 6/6 (2); in total, 6 in 100% (4).

et (n=2): 4/4 (2); in total, 4 in 100% (4).

eb_a (n=2): 4/4 (2); in total, 4 in 100% (4).

DISTRIBUTION. Italy (Friuli-Venezia Giulia: Udine), Slovenia (Gorenjska) (Fig. 71).

NOTES. *A. sigma* sp. n. is the westernmost species of the “mingrelicus complex” and the only species of this complex confirmed for Italy.

Alpiscorpius ypsilon sp. n.

(Figures 48–52, 71, Tables 1, 3–5)

<http://zoobank.org/urn:lsid:zoobank.org:act:EDAC8D3D-1DC4-4761-89BF-74929F05F81B>

org:act:EDAC8D3D-1DC4-4761-89BF-74929F05F81B

Euscorpius germanus “K-Form”: Scherabon, 1987: 87 (Austria).

Euscorpius gamma: Komposch & Scherabon, 1999: 621; Scherabon et al., 2000: 255 (Austria); Fet et al., 2001: 264 (Slovenia, in part); Komposch et al., 2001: 267; Sologlad & Sissom, 2001: 48; Kofler, 2002: 137; Fet et al., 2004: 55 (Slovenia, in part; Austria); Komposch, 2004: 447; Komposch, 2009: 359; Fet, 2010: 6 (Slovenia, in part; Austria); Graham et al., 2012: 42 (in part; Austria); Fet et al., 2016: 6.

Euscorpius (Alpiscorpius) gamma Karyotypic race III (Ega 86–92): Štundlová et al., 2019: 156.

TYPE LOCALITY AND TYPE DEPOSITORY. Slovenia, Gorenjska: Studenca, 46.246°N 14.678°E; NMPC.

TYPE MATERIAL (NMPC): 7♂2♀. Austria, Carinthia: Rechberg, 46.524°N 14.580°E, 1♂ (paratype No. S737). Slovenia, Gorenjska: Potoče, 46.302°N 14.441°E, 1♂ (paratype No. S738), Studenca, 46.246°N 14.678°E, 4♂ (holotype No. S739 and paratypes Nos. S793, S1080, S1081); Štajerska: Kozjak, 46.413°N 15.175°E, 1♂ (paratype No. S420) 2♀ (paratypes).

ETYMOLOGY. Di Caporiacco (1950) named three subspecies of *Euscorpius germanus* after the letters of the Greek alphabet *alpha*, *beta*, and *gamma*. We continue in this style for another cryptic species and name it *ypsilon* after Greek “ὕψιλόν”.

DIAGNOSIS. *Alpiscorpius ypsilon* sp. n. is a cryptic species of the “gamma group” of the “mingrelicus complex”, defined by Štundlová et al. (2019) as “Karyotypic race III (Ega 86–92)” which possesses a conspicuous variation in diploid chromosome number ranging from 86 to 92, both between and/or within populations (fig. S2C and D in Štundlová et al., 2019). There is polymorphism observed, presumably caused by the presence of chromosome fusion/fission events, resulted in four different karyotypes: $2n = 86$ (homozygous state, 43 bivalents), $2n = 87$ (heterozygous state, 42 bivalents and one trivalent), $2n = 90$ (heterozygous state, 42 bivalents and two trivalents), and $2n = 92$ (homozygous state, 46 bivalents). The rDNA clusters are located in the subterminal region of the short arms of the largest metacentric chromosome pair 1; in the case of karyotype $2n = 87$ it was detected on the heterozygous trivalent (fig. 2G and H, fig. S2C and D in Štundlová et al., 2019). Number of pectinal teeth (Dp) in male usually 8 (ca. 80% of examined specimens). Number of patellar ventral trichobothria (Pv) usually 5, more rarely 6. Reduction of patellar external trichobothria from 4 to 3 rare (<5%) in both groups *et* and eb_a (see also Notes).

Species	Locality	Female <i>P_v</i>	Offspring <i>P_v</i>	Female <i>P_e</i>	Offspring, <i>P_e</i>
<i>A. germanus</i>	Graschlitzen bei Warmbad Villach (Tab. 42)	<i>P_v</i> =5/5	5/5 (17), 6/5 (1), 5/4 (1); n=19	21/21	21/21 (14), 21/22 (3), 22/21 (2); n=19
<i>A. germanus</i>	Greifenburg an der Drau (Tab. 43)	<i>P_v</i> =5/5	5/5 (13), n=13	21/21	21/21 (12), 22/20 (1); n=13
<i>A. ypsilon</i>	Petzebgebiet (Tab 40)	<i>P_v</i> =5/5	4/5 (1), 5/5 (5), 5/6 (4), 6/5 (5); n=15	21/20	20/20 (1), 20/21 (3), 21/20 (3), 21/21 (7); 22/21 (1); n=15
<i>A. ypsilon</i>	Loibltal (Tab. 41)	<i>P_v</i> =5/5	5/5 (2), 5/6 (9), 6/5 (5), 6/6 (1); n=17	20/21	20/21 (1), 20/22 (1), 21/21 (9), 21/22 (3), 22/21 (2), 22/22 (1); n=17

Table 4. The comparison of trichobothrial numbers in *Alpiscorpius* spp. females and their offspring from Austria (after Scherabon, 1984). *P_e*, patella external series, total number.

DESCRIPTION OF THE MALE HOLOTYPE. The following description is based primarily on the holotype male. Measurements of the holotype are presented in Table 2. Carapace, tergites, and pedipalps reddish-black; carapace with some darker mottling; metasoma dark reddish-black with mottling; telson, legs, and sternites yellowish to reddish-brown; chelicerae light, slightly reticulated. Anterior edge of carapace essentially straight; smooth and lustrous, lacking any indication of carinae. There are two lateral eyes. Median eyes and tubercle are small in size. Tergites I–VII essentially smooth; tergite VII lacking lateral and median carinal pairs. Sternites III–VII smooth and lustrous; VII lacking lateral and median carinae. Stigmata are small, narrow elliptical. Metasomal segment V rather smooth and without carinae. Vesicle of telson swollen and elongated, with short highly curved aculeus. Vesicle essentially void of granules. Pectinal teeth number 8/8. Pedipalp carinae well-developed (Figs. 48–50). Movable fingers bear 7 rows of denticles with

external and internal denticles. Trichobothrial patterns type C, neobothriotaxic: chela ventral = 4/4; patellar *eb* = 5/4, *eb_a* = 4/4, *esb* = 2/2, *em* = 3/3, *est* = 3/3, *et* = 5/5; patellar ventral = 5/5. Tarsus of legs with single row of spinules on ventral surface.

VARIABILITY. We scored standard phenotypic markers for 7 type specimens (all ♂) with the following variation observed: *Dp* in males (n=7): 7/7 (1), 7/8 (1), 8/8 (5); in total, 7 in 21.43% (3), and 8 in 78.57% (11); mean = 7.79, SD = 1.48. *P_v* (n=7): 5/5 (4), 6/5 (3); in total, 5 in 78.57% (11) and 6 in 21.43% (3); mean = 5.21, SD = 0.50. *et* (n=7): 3/4 (1), 4/4 (6); in total, 3 in 7.14% (1), and 4 in 92.86% (13); mean = 3.93, SD = 0.27. *eb_a* (n=7): 4/4 (7).

DISTRIBUTION. Austria (Carinthia); Slovenia (Gorenjska, Štajerska) (Fig. 71).

NOTES. *Alpiscorpius ypsilon* sp. n. is the only species of the “gamma group” found in southern Austria (Karawanken Alps, Carinthia), and we currently assume that all Austrian records of “*Euscorpius gamma*” refer to this species (see references above). In Slovenia, *A. ypsilon* sp. n. is found only in the north; in the central part of Slovenia, it is replaced by *A. omega* sp. n., and in the west, by *A. omikron* sp. n.

Gantenbein et al. (2000) published 16S mtDNA sequence for a population of “*Euscorpius gamma*” from Koschuta (Austria, Carinthia, 46.45°N, 14.41°E), which closely matches sequences of Ega 86–92 (= *A. ypsilon* sp. n.) obtained independently by Štundlová et al. (2019). Two mtDNA sequences were published for another population of “*E. gamma*” from Trögerner-Klamm (Austria, Carinthia, 46.46°N, 14.50°E), which also closely match those of *A. ypsilon* sp. n. (16S mtDNA by Scherabon et al., 2000, and *CoxI* mtDNA by Graham et al., 2012).

Scherabon (1984, 1987) scored the standard phenotypic markers for a large series (>150 specimens) of this species in Austria (treated as “K-Form” of *Euscorpius germanus*), with the following results (recalculated here; *et* and *eb_a* data from Scherabon, 1984):

Dp in males (n=55): 6/7 (2), 7/7 (2), 7/7 (2), 7/8 (2), 8/7 (3), 8/8 (43), 8/9 (1), 9/8 (1), and 9/9 (1); in total, 6 in 1.82% (2); 7 in 8.18% (9), 8 in 86.36% (95), and 9 in 3.63% (4); mean = 7.90, SD = 0.49.

Dp in females (n=101): 5/5 (1), 5/6 (3), 6/5 (7), 6/6 (23), 6/7 (13), 7/6 (5), 7/7 (49); in total, 5 in 5.94% (12), 6 in 31.68% (64), and 7 in 62.38% (126); mean = 6.53, SD = 0.61.

Pv (n=162): 5/3 (1), 4/5 (3), 5/5 (83), 4/6 (2), 5/6 (22), 6/5 (30), 6/6 (21); in total, 3 in 0.31% (1), 4 in 1.54% (5), 5 in 68.52% (222) and 6 in 29.63% (96); mean = 5.27, SD = 0.50.

et (n=158): 1/4 (1), 4/2 (2), 3/4 (2), 4/3 (7), 4/4 (139) 4/5 (1), 5/4 (40), 5/5 (2); in total, 1 in 0.31% (1), 2 in 0.63% (2), 3 in 2.85% (9), 4 in 93.35% (295), and 5 in in 2.85% (9); mean = 3.98, SD = 0.33.

eb_a (n=158): 2/4 (2), 4/2 (1), 3/4 (6), 4/3 (6), 4/4 (143); in total, 2 in 0.94% (3), 3 in 3.80% (12), and 4 in 95.25% (301); mean = 3.94, SD = 0.27.

Note that *Pv* distribution in this species (mean=5.27) is bimodal: out of 162 specimens scored, *Pv*=5 was present in 68.5% of pedipalps, *Pv*=6, in 29.6%; only 13% had *Pv*=6/6. These phenotypic data are consistent with the type series. The reduction from 4 to 3 of both *et* and *eb_a* is rare (<5%) in Austrian specimens; the small type series (n=7) has only one pedipalp with *et*=3, and none with *eb_a*=3.

Discussion

Cryptic diversity. Štundlová et al. (2019) clearly demonstrated existence of several distinct karyotypic races in *Alpiscorpius* based on integrative approach combining cytogenetic and DNA sequence data. In this paper, we assigned the karyotypic races of Štundlová et al. (2019) to the existing or new species, most of them allopatric. Further morphological distinguishing among the cryptic species (especially of “*mingrelicus*

complex”) might become possible after a detailed study of their phenotypic variation in large samples, including traditional variable traits such as number of pectinal teeth, trichobothria on ventral and external surface of pedipalp patella (especially in the groups *et* and *eb_a*), *et-est/est-dsb* distance ratio on fixed finger, and granulation on the metasoma V.

More cryptic diversity is seen in the eastern part of the studied area, within the northwestern part of the range of “*mingrelicus* complex”. Fet et al. (2001) listed numerous Slovenian populations of “*Euscorpius gamma*” and noted their “patchy distribution” across the complex mountainous landscapes. These records, as we see now, could refer to at least five cryptic, allopatric species of the “gamma group”, four of which are described above. Among them, *A. omega* sp. n. has the widest distribution in the eastern and central part of Slovenia while *A. omikron* sp. n. (west) and *A. ypsilon* sp. n. (northeast; also found in Austria) are more localized, and *A. sigma* sp. n. is so far found only in the very northwestern corner of Slovenia and the bordering northeastern corner of Italy (Udine; Fig. 71).

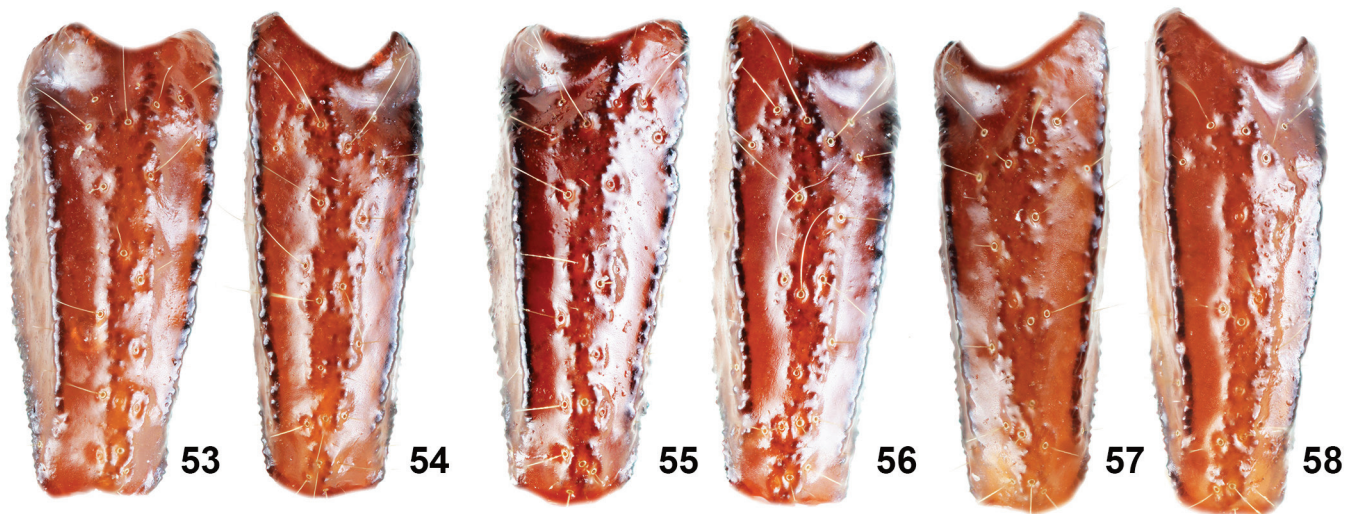
Reduction of trichobothrial number. The traditional genus *Euscorpius* is notable for highly variable trichobothrial number in pedipalp patella (both ventral and external aspects). This variation has been documented at all levels including interspecific and intraspecific patterns, reflecting a secondary loss of accessory trichobothria (Soleglad & Fet, 2004) in neobothriotaxia taxa (Vachon, 1974).

Some of the fixed trends of reduction in independent clades have been confirmed by phylogenetic studies (Parmakelis et al., 2013). The genus *Alpiscorpius*, stat. n., is well-known for reduction in *em* group from 4 to 3 (Tropea et al., 2015). It is interesting that the same trend has been independently observed in other, unrelated clades of *Euscorpius* s.l., including geographically marginal *E. carpathicus* (L., 1767), *s.str.* (Romania) and *E. drenskii* Tropea et al., 2015 (Bulgaria).

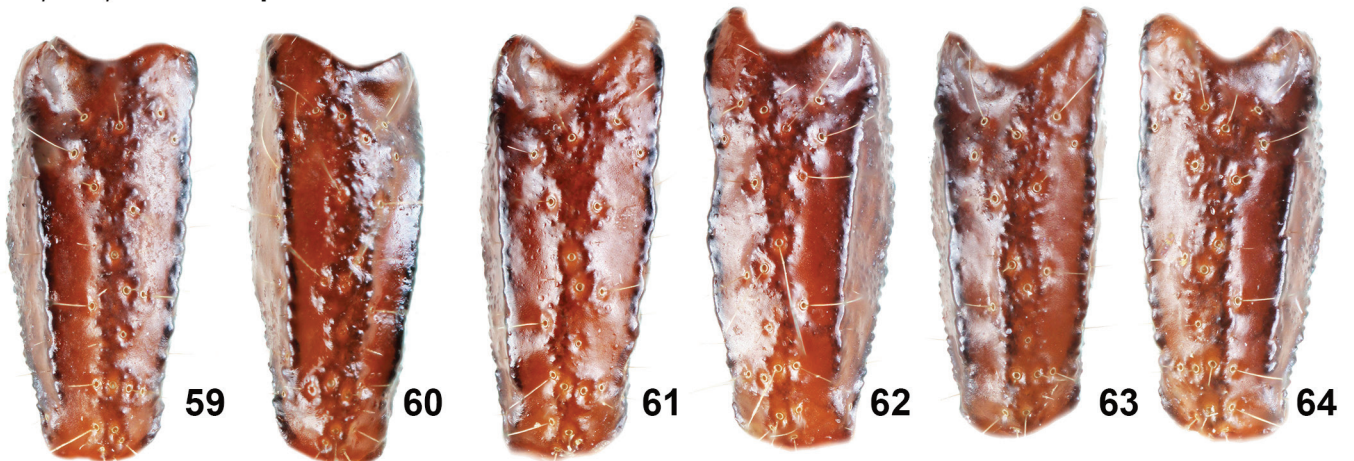
Another clear trend is a reduction in external terminal patellar trichobothria (*et*). We have seen above that a reduction from *et*=4 to 3 is common in the genus *Alpiscorpius*. A similar reduction from *et*=6 to 5 has been observed in *Euscorpius* s.l. in a number of localized island or mountain endemics such as *E. avcii* Tropea et al., 2012 (Parmakelis et al., 2013) from Samos Island and Anatolia, *E. ossae* Di Caporiacco, 1950 from Mt. Ossa (Fet et al., 2013b), or an undescribed form from the Andros Island, Greece (Fet et al., 2013a).

The same trend was often documented for the *Pv* series, where *Pv*=6 to 5 reduction can be seen in several clades of *Alpiscorpius*, with fixation of stable *Pv*=5 (and minimal known for the genus) in several species, including *A. germanus*.

A dramatic pattern of trichobothrial number reduction was documented by Soleglad & Fet (2004, Tab. VIII) for the highly isolated *E. balearicus* (Di Caporiacco, 1950) from the Balearic Islands (Spain) for both *et* and *Pv*. Compared to the largest island, Mallorca, both series are reduced of 9.77/16.17% in the smaller island of Menorca; even a larger reduction is seen in the quite small Cabrera Island (17.88/17.30%). In the *et* group,



Alpiscorpius lambda sp. n.



Alpiscorpius omega sp. n.



Alpiscorpius omega sp. n.

Alpiscorpius omikron sp. n.

Figures 53–70: Comparison of variability in position and numbers of external patellar trichobothria. **Figures 53–58.** *Alpiscorpius lambda* sp. n., three males paratypes (Nos. S787–S789). **Figures 59–64.** *A. omega* sp. n., three males paratypes (Nos. S741–S743). **Figures 65–70.** *A. omikron* sp. n., male (S693), female (S696) and male (S697) paratypes.

	Distribution	Male Dp	<i>Pv</i>	<i>et=3</i> reduction	<i>eb_a=3</i> reduction
<i>Alpiscorpius germanus</i> complex					
<i>A. alpha</i>	Italy (N), Switzerland (Ticino, Grisons)	usually 7	usually 6	common (>10%)	very common (>25%)
<i>A. beta</i>	Italy (NW), Switzerland (Valais)	usually 8	usually 5–6	rare (< 10 %)	common (>10%)
<i>A. delta</i>	Italy (N)	usually 7	usually 5	rare (< 10 %)	common (>10%)
<i>A. germanus</i>	Austria, Italy (NE), Switzerland (Grisons)	usually 8	usually 5	common (>10% in Italy)	very common (up to 25% in Italy)
<i>A. kappa</i>	Slovenia	usually 7	usually 5	none	common (20%)
<i>A. lambda</i>	Slovenia	usually 7–8	usually 5	none	dominant (70%)
<i>Alpiscorpius mingrelicus</i> complex					
<i>A. omega</i>	Slovenia	usually 8	usually 5	very common (25%)	none
<i>A. omikron</i>	Slovenia	usually 8, more rarely 7	usually 6	very common (>25%)	very common (25%)
<i>A. sigma</i>	Italy (NE), Slovenia (NW)	usually 8	usually 6	none	none
<i>A. ypsilon</i>	Austria (Carinthia), Slovenia (N)	usually 8	usually 5, more rarely 6	rare (< 5 %)	rare (< 5 %)

Table 5. Diagnostic table of studied *Alpiscorpius* spp. (based on examined material; see also Notes under species).

there was even a reduction from Cabrera to the adjacent tiny islets, 3.07%. In this example, the reduction in the number of trichobothria seems to follow the species' radiation (through either vicariance or dispersal).

We suggest that *Pv*, *eb_a=3* and *et=3* reduction represents an important trend in local phenotypic variation in many (but not all) species of *Alpiscorpius* (likely due to their isolation during glacial periods; see Štundlová et al., 2019, for a detailed discussion). It could provide a useful marker for microevolutionary studies at population level.

Asymmetry and heritability. Bonacina (1980) suggested existence of hybridization between the *Alpiscorpius* taxa (his subspecies *E. g. alpha* x *E. g. germanus*, and *E. g. germanus* x *E. g. marcuzzii*). For instance, he postulated the number of ventral patellar trichobothria as *Pv* = 5 for *E. g. germanus* and *Pv* = 6 for *E. g. alpha*, and suggested a hybridogenic origin for populations in the Bergamascan Alps (Valle Brembana, north of Bergamo) because of the mixed numbers (5/5 or 6/6), and a high number of asymmetric (5/6 or 6/5) individuals.

We find no evidence for hybridization between currently recognized taxa, which are generally allopatric and well-defined at species level (we do not recognize any subspecies

in *Alpiscorpius*). On the other hand, fluctuating asymmetry in scorpions is common but its heritability has not been assessed. We have come across the only known to us scorpion data comparing trichobothrial variation in a female and her offspring. The unpublished PhD dissertation of Bernhard Scherabon (1984), kindly shared with us by its author, among much relevant statistics of *A. germanus* ("T-Form") and *A. ypsilon* sp. n. ("K-Form") from Austria, contains intriguing pilot data (not published in the subsequent monograph by Scherabon, 1987). included pectinal teeth and trichobothrial counts for two females of *A. germanus* ("T-Form") and two females of *A. ypsilon* sp.n. (as "K-Form" of *E. germanus*) and their offspring. These trichobothrial data from Scherabon (1984) are summarized in Table 4.

An immediate observation that while 5/5 females of *A. germanus* (a species that normally has *Pv*=5) have mainly 5/5 offspring, the 5/5 females of *A. ypsilon* (where both *Pv*=5 and 6 are common) can have large number of 5/6 and 6/5 offspring. This tempts one to treat *Pv* values as an expression of simple single-locus Mendelian characters, with a suspected 6/6, 6/5 or 5/6 father phenotype in *A. ypsilon*! In this case, asymmetric individuals are heterozygotes, with incomplete dominance. A similar pattern of inheritance is observed in external trichobothria. Scherabon (1984) did not specify the individual trichobothrial

groups but the total number 21 indicates non-reduced $et=eb_a=4$, while number 20 means that one of these groups is reduced to 3; number 22 indicates a rare increase to $et=5$.

Even if though such a mechanism of quantitative inheritance appears too simplistic (since quantitative traits are usually encoded by more than one gene), the hypothesis should be tested. Rare values of Pv or et could then represent rare alleles of the same locus, or be a result of epistasis from other loci. This is consistent with a hypothesis that “fluctuating asymmetry has a predominantly nonadditive genetic basis with substantial dominance and especially epistasis” (Leamy & Klingenberg, 2005).

If true, variation in number of asymmetric individuals reflects heterozygosity of a population, and we observe a rare, easily quantifiable phenotypic marker, exhibited in many species. Beyond *Alpiscorpius*, in the genus *Euscorpius* s.str., variation of Pv and et exhibits similar patterns of distribution and asymmetry. Homozygous genotypes, therefore, could be fixed by genetic drift in some allopatric populations/species, leading to phenotypic expression such as $Pv=6$ in *A. alpha* and $Pv=5$ in *A. germanus*.

A Key to the Studied *Alpiscorpius* Species (see also Table 5)

1. Trichobothrial *et-est/est-dsb* ratio on fixed finger around 1 (“*germanus* complex”). 2
 - Trichobothrial *et-est/est-dsb* ratio on fixed finger around 2 (“*mingrelicus* complex”). 7
2. West of Adige (Etsch) River (Italy, Switzerland). Number of ventral patellar trichobothria 5 to 6 (“*alpha* group”). ... 3
 - East of Adige (Etsch) River: Italy, Switzerland (Grisons: Val Müstair only), Slovenia, Austria. Number of ventral patellar trichobothria usually 5 (“*germanus* group”). 5
3. Number of pectinal teeth in male usually 8. Number of ventral patellar trichobothria varies between 5 and 6. Italy (northwest: Piedmont, Val d’Aosta), Switzerland (Valais: Simplon) . *A. beta* (Di Caporiacco, 1950), **comb. n.**, **stat. n.**
 - Number of pectinal teeth in male usually 7. 4
4. Number of ventral patellar trichobothria usually 5; $eb_a=3$ reduction common (>10%), Italy (northeast: Lombardy)... *A. delta* **sp. n.**
 - Number of ventral patellar trichobothria usually 6; $eb_a=3$ reduction very common (>25%). Italy (Piedmont), Switzerland (Ticino, Grisons). *A. alpha* (Di Caporiacco, 1950), **comb. n.**
5. Number of pectinal teeth in male usually 8. $et=3$ reduction common (>10% in Italy); $eb_a=3$ reduction very common (up to 25% in Italy). Austria, Italy, Switzerland (Grisons: only Val Müstair). ... *A. germanus* (C. L. Koch, 1837), **comb. n.**
 - Number of pectinal teeth in male 7 to 8; $et=3$ reduction is absent; Slovenia. 6

6. Number of pectinal teeth in male usually 7; $eb_a=3$ reduction is common. Slovenia (northwest). *A. kappa* **sp. n.**
 - Number of pectinal teeth in male 7 to 8; $eb_a=3$ reduction is dominant. Slovenia (west), ?Italy (northeast). *A. lambda* **sp. n.**
7. Metasoma V ventrally finely granulated and with lateral carinae indicated by several solitary granules. Italy (northeast), Slovenia (northwest). *A. sigma* **sp. n.**
 - Metasoma V smooth or very finely granulated. 8
8. Number of ventral patellar trichobothria usually 6. Both $eb_a=3$ and $et=3$ reduction are very common. Slovenia (west). *A. omikron* **sp. n.**
 - Number of ventral patellar trichobothria usually 5. 9
9. No $eb_a=3$ reduction but $et=3$ reduction is very common (>25%). Slovenia (central). *A. omega* **sp. n.**
 - $et=3$ and $eb_a=3$ reduction rare (< 5% in Austria), Slovenia (north), Austria (Carinthia: Karawanken Alps). *A. ypsilon* **sp. n.**

NOTE. We do not include *A. gamma* (Di Caporiacco, 1950) in this key since it requires further study; currently, we restrict this species to its type locality in SW Slovenia (mouth of the Rižana River).

Identity of *Euscorpius germanus mesotrichus* Hadži, 1929

Euscorpius germanus mesotrichus Hadži, 1929: 38, fig. 7, tab. VII. <http://zoobank.org/urn:lsid:zoobank.org:act:6A24C6AD-2CA7-40D4-8E46-B63A2D506F6D>

The identity of this old taxon described from Slovenia (syntypes: 3♂7♀, depository unknown), is unclear. It was listed as a subjective junior homonym of *Euscorpius italicus mesotrichus* Hadži, 1929 (Fet & Sissom, 2000: 366); however, with the elevation of the subgenus *Alpiscorpius* this name technically becomes available as “*Alpiscorpius mesotrichus*”. Its vague type locality was indicated as “bivša [=former] Kranjska”. Kranjska (or Carniola) is a historical region, which refers to three regions of the modern Slovenia (Gorenjska, or Upper Carniola; Notranjska, or Inner Carniola; and Dolenjska, or Lower Carniola). Table VII in Hadži (1929) lists syntype males with $Dp=7$ or 8 and females mostly with $Dp=6$; number of ventral trichobothria Pv varies between 5 and 6, and number of external trichobothria is usually 21 (i.e. $et=eb_a=4$); his fig. 7 clearly shows $et=eb_a=4$ without reduction. In our opinion, the syntype series of this taxon could refer to several new species described here from Slovenia (see our Table 5), and most likely not from “*germanus*” but from “*mingrelicus* complex”. However, unless the syntype series is rediscovered and studied, the name “*Alpiscorpius mesotrichus* (Hadži, 1929)” cannot be used since it is not currently associated with any valid species.

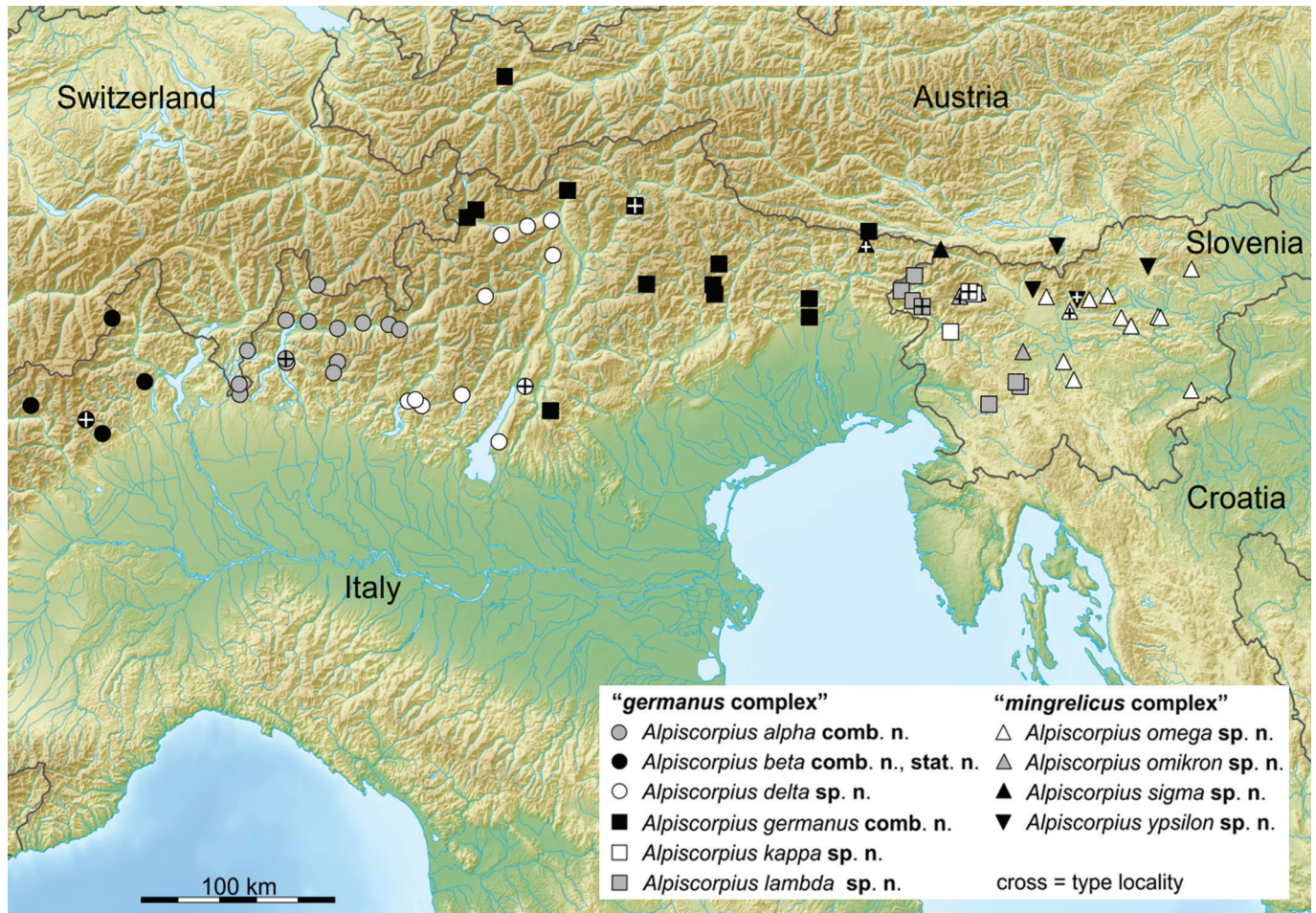


Figure 71. Map showing confirmed distribution of studied species of *Alpiscorpius*, stat. n.

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