The *Erigone psychrophila* group in the Alps (Araneae: Linyphiidae)

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ABSTRACT Contrib. Nat. Hist. 12: 987–1005.

Three closely related species of the *Erigone psychrophila* group from the Alps are redescribed: *E. cristatopalpus* Simon, 1884, *E. tenuimana* Simon, 1884 and *E. tirolensis* L. Koch, 1872. The female of *E. tenuimana* is described for the first time. We show that *E. tenuimana*, a forgotten species for more than 70 years, is widespread across the whole Alpine arc. The frequent confusion of these species in the past calls for revision of all previous records. Morphometric analysis suggests that body size and dentition of chelicerae are useful discriminating characters in addition to genital morphology. *Erigone cristatopalpus* and *E. tenuimana* dwell in open habitats of the subalpine and alpine zones, where they can occur together. *Erigone tirolensis* is restricted to high alpine and subnival habitats, the first record from Germany (Krottenköpfel) refers to *E. tenuimana*. Transatlantic relationships with *E. aletris* Crosby & Bishop, 1928 and *E. zographica* Crosby & Bishop, 1928 are discussed.

Introduction

The dwarf spider genus *Erigone* still holds surprises for European arachnologists, recall for example the new description of *Erigone jägeri* Baehr, 1984 from southern Germany (Baehr 1984), or the first record of the Nearctic *E. autumnalis* Emerton, 1882 in Europe (Hänggi 1990, 1993). Despite the mass occurrence and widespread distribution of some of the aeronautic species, the genus also comprises species with limited ranges. Species of the *E. psychrophila* group (sensu Crosby & Bishop 1928) are restricted to arctic and alpine habitats. Crosby & Bishop (1928) included three European species in this group. *Erigone cristatopalpus* Simon, 1884 and *Erigone tirolensis* L. Koch, 1872 were thoroughly characterized by Thaler (1978). However, the last record of the third species, *E. tenuimana* Simon, 1884, goes back to Schenkel (1929).

This species is not mentioned in the comprehensive surveys of the spider fauna of North Tyrol (Thaler 1999) or the Bavarian Alps (Muster 2001), while it was treated as an uncertain record in the Catalogue of Swiss Spiders (Maurer & Hänggi 1990). Some years ago the authors examined samples from Weissenberge (Switzerland, Canton Glarus) and Geigelstein (Germany, Chiemgau Alps), respectively, containing specimens that seemed to be close to but nevertheless distinctly different from *E. cristatopalpus* and *E. tirolensis*. The specimens resembled *Erigone aletris* Crosby & Bishop, 1928, a species of the American lowlands (Crosby & Bishop 1928) and Great Britain (Snazell 1980, Roberts 1987), but its occurrence in the alpine zone was not very likely. It was the late Konrad Thaler, to whom we dedicate this paper, who suggested to compare the specimens with the long forgotten *E. tenuimana*, of which only descriptions of the male existed (Simon 1884, Kulczyński 1902). Here we show that *E. tenuimana* is in fact widespread across the Alps and that it had been frequently mixed up with *E. cristatopalpus* in the past decades. We provide redescriptions of all three species and discuss the diagnostic characters.[1]

Material and Methods

Material

The material examined originates from the following private and public collections:

AMNH	American Museum of Natural History New York
CL	Collection Dorothee Leipold
CM	Collection Christoph Muster
CT	Collection Konrad Thaler
MHNG	Muséum d'histoire naturelle de la ville de Genève
MNHN	Musée national d'histoire naturelle Paris
NMB	Naturhistorisches Museum Basel

[1] Submitted on 30 November 2006.

Morphometric analysis

The morphometric analyses are based on measurements of 10 males of each species and 12, 8 and 6 females of *E. cristatopalpus*, *E. tenuimana* and *E. tirolensis*, respectively. We collected data on carapace length and width, the length of five segments of leg I (femur, patella, tibia, metatarsus, tarsus) and the number of teeth in the anteriolateral row of the chelicerae. In males, we measured also cymbium length and the length of femur, patella and tibia of the palp. Mean centered coefficients of variation (CoV = standard deviation/ mean x 100%) were calculated as a standardized measure of variation. We applied discriminant analysis as a test of morphometric separation of the three species. A discriminant analysis was conducted for males and females separately with stepwise addition of variables. All calculations were run with SPSS 11.0 for Windows. All measurements are given in mm.

Terminology of genitalia

Wiehle (1960: figs. 1057, 1062) distinguished three apophyses of the male palpal tibia in the genus *Erigone*, ventral, dorsal and lateral apophysis. While the *ventral apophysis* (vA) is always present, the *dorsal apophysis* (dA) is, if existent, in species of the *psychrophila* group only a small lamellar process (Fig. 1a). Instead of an apophysis, some species show a distinct *notch* on the dorsal ridge of the tibia (dN, Fig. 1b). We avoid the term "lateral apophysis", as this is not really an apophysis. In fact in the *psychrophila* group the tibia is rather excavated on the retrodorsal third. This *tibial pit* (tP, Fig. 1a) is flanked by an apophysis-like structure at the retrolateral side. We use *retrolateral border of pit* (rB) instead of lateral apophysis [= "retrolaterale Apophyse", Thaler 1978].

The terminology of the processes of the embolic division (Fig. 3) largely follows Crosby & Bishop (1928). The central *scaphium* (S) is armed with three teeth and a process on the mesal side. We adopt the terms *anterior tooth* (aT) [= da "dens anticus", Wiehle 1960: fig. 1047], *median tooth* (mT) [= dm "dens medius", Wiehle 1960], *posterior tooth* (pT) [= dp "dens posterior", Wiehle 1960] and *scaphium tooth* (sT) [= ds "Zahn des Scaphiums", Wiehle 1960; "mesal tooth", Crosby & Bishop 1928).

The posterior margin of the epigyne (Figs. 4a–c) often shows a gap in sclerotisation, the *notch* (eN). The scape of the epigyne is folded laterally, making *lateral plates* (lP) visible in dorsal view [= "posterior plate", Holm 1975]. The lateral plates border a more or less triangular excavation, the *epigynal groove*

(eG). The central part of the vulva is the *median plate* (mP) [= "vestibulum", Holm 1975; "Mittellappen", Wiehle 1967].

Results

Taxonomy

The three species discussed below belong to the *psychrophila* group sensu Crosby & Bishop (1928). Males of this group are characterised by a distinct pit on the retrolateral third of the palpal tibia which is bordered by an apophysis-like structure. The median tooth of the embolic division is prominent, curved over the scaphium and exhibits rippled structures distally. We suggest that females of this group could be characterised by the widely separated, elongated receptacula which show a certain degree of division into two components (like boxing gloves).

The number of tibial spines (2,2,2,1) and the presence of trichobothria on the metatarsi (1,1,1,0) corresponds to the general pattern in the genus *Erigone*. We could not observe diagnostically relevant differences in colouration between the three species investigated. Carapace, chelicerae and sternum are dark brown, legs uniformly yellowish to light brown, abdomen grey. On average males are slightly larger than females.

***Erigone cristatopalpus* Simon, 1884** (Figs. 1a, 2a, 3a, 4a, d, g)

E. cristatopalpus; Simon (1884): 525, figs. 318–320. – Kulczyński (1902): 545, pl. 35, figs. 9, 25. – Jackson (1930): 648, pl. XVII, figs. 2, 5. – Miller (1971): 266, pl. LV, figs. 15–18. – Locket (1973): 165, fig. 4A.

E. cristatipalpus; Bonnet (1956): 1759. – Thaler (1978): 185, figs. 26–30 (in part, ♂ only).

Material examined:

AUSTRIA: *North Tyrol*. Zillertaler Alps. Wolfendorn, 1800 m, 2 ♂ 13. 7. 1962, leg. K. Thaler (CT E-837, nT62/117) [Thaler 1978, 1999]. Stubai Alps. Kühtai, Stocktalbach, 2400 m, 4. 10.–14. 10. 1982, leg. Ritter (CT) [Thaler 1999]. *Vorarlberg*. Lechtal Alps. Zürser See-Madljoch, 2000–2300 m, leg. K. Thaler (CT E-834, Vbg 63/1) [Thaler 1978].

FRANCE: *Drôme*. Crest, 1 ♀ (MNHN, Coll. E. Simon) [together with 10 ♂ of *E. tenuimana*].

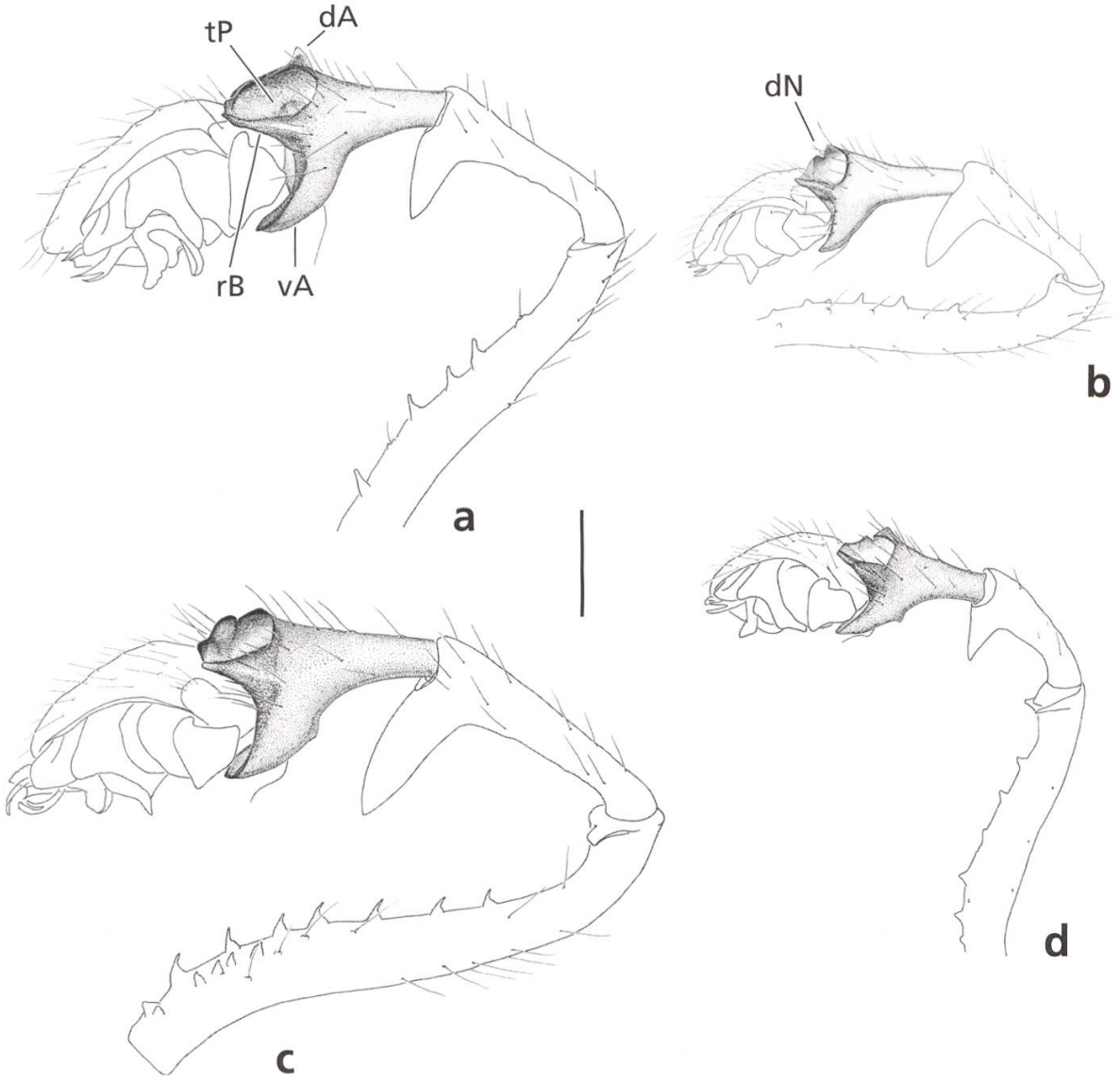

Fig. 1. Male palp, left, retrolateral. – a: *E. cristatopalpus*; – b: *E. tenuimana*; – c: *E. tirolensis*; – d: *E. aletris*. Scale 0.2 mm. dA = dorsal apophysis, dN = dorsal notch, rB = retrolateral border of tibial pit, tP = tibial pit, vA = ventral apophysis.

GERMANY: *Bavaria*. Berchtesgaden Alps. Funtensee, 1630 m, 1 ♂ 29. 9. 2005, leg. Nationalparkverwaltung (CL). Chiemgau Alps. Geigelstein/Rossalpenkopf, below snow pocket, 1700 m, 3 ♂ 1 ♀ 29. 7. 1999, leg. C. Muster (CM A1091) [Muster 2001]. Schliersee Mts. Grünsee, 1360 m, 1 ♂ 4. 7. 1992, leg. O. Fischer-Leipold (CL) [Muster & Leipold 1999]. Karwendel. Fereinalm, alpine pasture, 1450 m, 1 ♀ 10. 8. 1998, leg. R. Krause (CM A0643) [Muster & Leipold 1999, Muster 2001]. Wettersteingebirge. Schachen, Frauenalpl, 2010–2320 m, 2 ♂ 4 ♀ 30. 8.–29. 9. 1999, leg. Merk/Voith (CL). Ammergebirge. Frieder, Rotmoos, *Carex rostrata* reed, 1170 m, 27. 5.–21. 6. 1998, leg. Voith (CL) [Muster & Leipold 1999]. Allgäu Alps. Breitenberg near Pfronten, *Carex davalliana* reed, 1700 m, 2 ♂ 14. 9.–19. 10. 2003, leg. Merk/Voith (CL).

SWITZERLAND: *Graubünden*. Mesocco, Bosch de San Remo, peat bog, 1630 m, 1 ♂ 14. 6.–26. 6. 1991, leg. F. Rampazzi (NMB 1526d). Davos, 1 ♂ 1 ♀ 3. 5.–6. 6. 1979, leg. Wartmann (NMB 1526j, ex Coll. R. Maurer). Val Curciusa, 2000–2200 m mixed up samples with no detailed information, 15 ♂ 9 ♀, (NMB). *Ticino*. Val Bedretto, Alpe di Folera, 1900–2100m, 1 ♂ 30. 7. 1928, leg. E. Schenkel (NMB1526a,b – mixed up series with 1 ♂ from Fiesch, Bettmersee, Valais) [Schenkel 1929]. Airolo, Pian Secco, peat bog transition zone, 1850 m, 2 ♂ 2 ♀ 28. 5.–3. 6. 1992, leg. F. Rampazzi (NMB 1526e). Quinto, Canariscio di Ritom, peat bog, 1950 m, 2 ♂ 26. 6.–3. 7. 1992, leg. F. Rampazzi (NMB 1526f). Quinto, Cadagno di Fuori, peat bog, 1915 m, 2 ♂ 26. 6. 1992, leg. F. Rampazzi (NMB 1526i). Olivone, Frodalera, peat bog, 1760 m, 2 ♀ 9. 6. 1992, leg. F. Rampazzi (NMB 1526g). Osco, Nei Pini, peat bog transition zone, 2020 m, 1 ♀ 1. 7.–10. 7. 1992, leg. F. Rampazzi (NMB 1526h). *Valais*. Fiesch, Bettmersee, 2006 m, 1 ♂, VIII, leg. E. Schenkel (NMB 1526a,b – mixed up series with 1 ♂ from Val Bedretto, Ticino).

Diagnosis: Within the *E. psychrophila* group, this species shows affinities to both *E. tenuimana* and *E. tirolensis*. Males differ in the exceptionally long median and posterior teeth of the embolic division (Fig. 3a), the presence of a lamelliform apophysis at the dorsal ridge of the palpal tibia and the larger pit compared to the length of the tibia (Fig. 1a). The shape of the palpal tibia also resembles *E. svenssoni* Holm, 1975, which is, however, characterized by a long spur on the ventral apophysis. Females of *E. cristatopalpus* show stronger dentition at the anterolateral margins of the chelicerae (Fig. 4g) than *E. tenuimana* and *E. tirolensis* (Figs. 4h–i). For relationships with the Nearctic *E. zographica* Crosby & Bishop, 1928 see remarks.

Male: Carapace: Length 1.02–1.26, width 0.78–0.96, cephalic part elevated, lateral margin with 13–16 teeth.

Chelicerae (Fig. 4d): Row of anteriolateral tubercles with 4–6 prominent teeth, the median ones the largest, alongside the fang with 5 promarginal and 4 retromarginal teeth.

Legs: Length of leg I: Fe 0.72–0.92, Pa 0.22–0.28, Ti 0.62–0.80, Mt 0.50–0.68, Ta 0.42–0.50.

Male palp (Figs. 1a, 2a, 3a): Fe 0.66–1.00, with 5–7 prolateral knobs or teeth in lateral view. Pt 0.28–0.60, with large, variable apical apophysis. Ti 0.30–0.50, with a large pit on the retrodorsal end reaching more than 1/3 of tibia length, dorsal ridge of the pit with triangular lamelliform apophysis, retrolateral border with apophysis-like lanceolate structure, ventral apophysis usually without tooth but sometimes with small denticle. Embolic division with four teeth in the typical arrangement of the *psychrophila* group as defined by

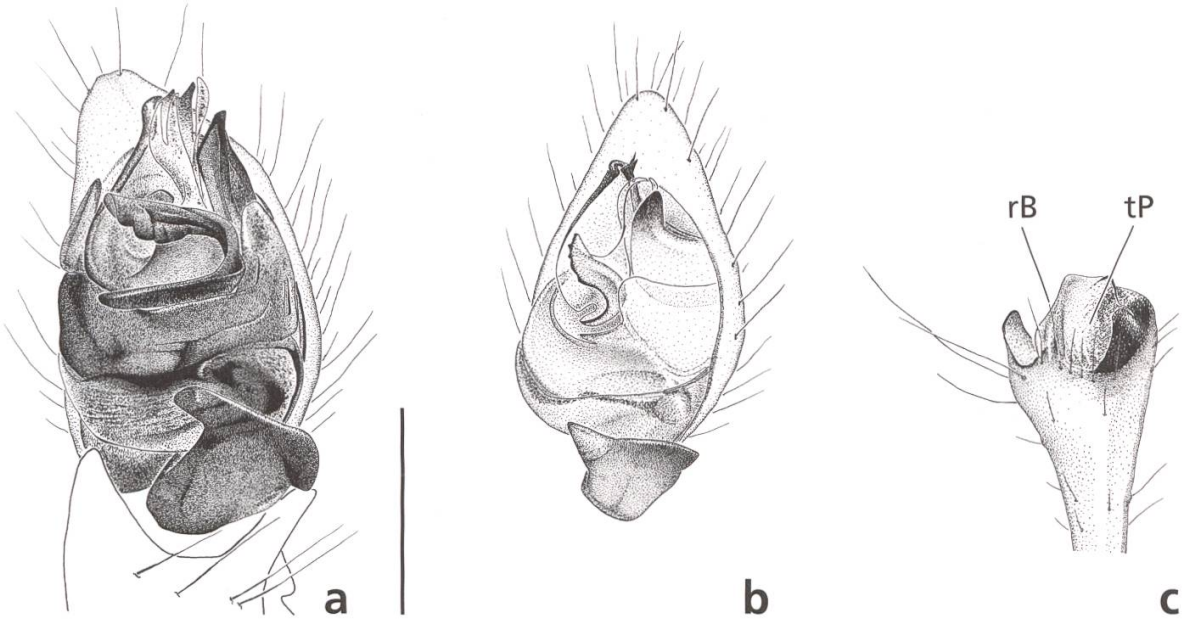

Fig. 2. Male palp, bulbus genitalis ventral (a, b) and tibia dorsal (c). – a: *E. cristatopalpus*; – b, c: *E. tenuimana*. Scale 0.2 mm. rB = retrolateral border of tibial pit, tP = tibial pit.

Crosby & Bishop (1928). Median tooth prominent with numerous ripples along posterior margin, posterior tooth conspicuous, as long as median tooth.

Female. Carapace: Length 0.92–1.20, width 0.72–0.94, lateral margin with tiny denticles.

Chelicerae (Fig. 4g): Row of anteriolateral tubercles with 4–5 prominent teeth, the two distal ones of largest size, almost as long as in males, sometimes with an additional small apical tubercle; alongside the fang with 5 promarginal and (3–) 4 retromarginal teeth.

Legs: Length of leg I: Fe 0.68–0.88, Pa 0.20–0.26, Ti 0.58–0.82, Mt 0.5–0.76, Ta 0.4–0.52.

Epigyne/vulva (Fig. 4a): Width of scape approximately 0.28 mm, posterior margin smoothly rounded, weakly sclerotised, notch inconspicuous. Median plate tongue-like. Lateral plates narrow, run of inner margin similar to outer margin. Receptacula widely separated from each other, widest distance between outer margins approximately 0.25 mm. Length of receptacula 0.11 mm.

Remarks: Our results show that the two species *E. cristatopalpus* and *E. tenuimana* have not been correctly recognized and distinguished for many decades. Many samples stored under "*E. cristatopalpus*" contained specimens of both species, sometimes even within the same vial. We therefore conclude that all records of the post-Simon era need to be re-examined. Furthermore, this species is almost identical to *E. zographica* Crosby & Bishop, 1928 (cf. also Schenkel 1950: figs. 17a–d; Paquin & Dupérré 2003: figs. 1028–1033) from North America. For biogeographic reasons, however, we hesitate to synonymize the two species without being able to examine large series of each.

Distribution: Endemic to the Alps, where the species is apparently distributed across the whole Alpine arc (Fig. 6). The vertical distribution comprises the subalpine and alpine zones from approximately 1300 to 2900 m a.s.l. A preference for wet habitats, such as peat bogs, *Carex* reeds and lakesides, is evident. Syntopic and synchronous occurrence with *E. tenuimana* has been observed (e.g. Geigelstein, Fereinalm).

***Erigone tenuimana* Simon, 1884** (Figs. 1b, 2b, c, 3b, 4b, e, h)

E. tenuimanus; Simon (1884): 522, figs. 313–314. – Kulczyński (1902): 545, pl. 35, figs. 27, 41, 53.

E. cristatopalpus leptocarpus Simon, 1884; Simon (1884): 526, fig 320 (Simon 1926: 519).

E. cristatipalpus; Thaler (1978): 185, fig. 25 (in part, ♀ misidentified).

Material examined:

AUSTRIA: *Salzburg*. Hofgastein, Schlossalm, 1900 m, 2 ♂ 1982 (CT). *North Tyrol*. Kitzbühl Alps. Fieberbrunn, Wildseealm, 1600 m, 6 ♀ 2. 9. 1962, leg. K. Thaler (CT nT 62/148) [Thaler 1978, sub *E. cristatipalpus*].

FRANCE: *Drôme*. Crest, 10 ♂ (MNHN, Coll. E. Simon) [most likely this is the sample mentioned by Simon 1926, p. 519 from Dept. Drôme, this sample contained also 1 ♀, but re-examination showed that it belongs to *E. cristatopalpus*].

GERMANY: *Bavaria*. Chiemgau Alps. Geigelstein/Rossalpenkopf, below snow pocket, 1700 m, 1 ♂ 29. 7. 1999, leg. C. Muster (CM A1090). Karwendel. Fereinalm, alpine pasture, 1450 m, 1 ♂ 27. 6.–17. 7. 1998, leg. C. Muster (CM A0643) [Muster & Leipold 1999, Muster 2001; sub *E. cristatopalpus*]. Ammergebirge. Krottenköpfel, subalpine pasture, 1750 m, 3 ♂ 14. 6.–19. 7. 1991, leg. G. Schmidt (NMB) [Schmidt 1994, sub *E. tirolensis*]; Frieder, Lausbichl, *Nardus* pasture, 1950 m, 3 ♂ 2 ♀ 27. 5.–21. 6. 1998, 5 ♂ 4 ♀ 21. 6.–12. 7. 1998; Friederspitz, 1960 m, *Carex sempervirens* grassland, 8 ♂ 27. 5.–21. 6. 1998, leg. Voith (CL) [Muster & Leipold 1999, sub *E. cristatopalpus*].

ITALY: *Southern Tyrol*. Brixen, Plose-Pfannspitze, 2450–2500 m, 2 ♂ 22. 6. 1963, leg. K. Thaler (CT ST 63/3) [Thaler 1978, sub *E. cristatipalpus*].

SWITZERLAND: *Glarus*. Weissenberge, subalpine pasture, 7 ♂ 17. 7. 1993, leg P. Wiedemeier. Weissenberge, 4 ♂ 1 ♀ without further information, leg. P. Wiedemeier (NMB). *Ticino*. Val Bedretto, Bedretto to Alpe di Folera, 1400–1800 m, 1 ♂ 11.–22. 7. 1927, leg. E. Schenkel (NMB 1533a, b – mixed up series with 1 ♂ from Fiesch, Valais) [Schenkel 1929]. *Valais*. Fiesch, Hotel

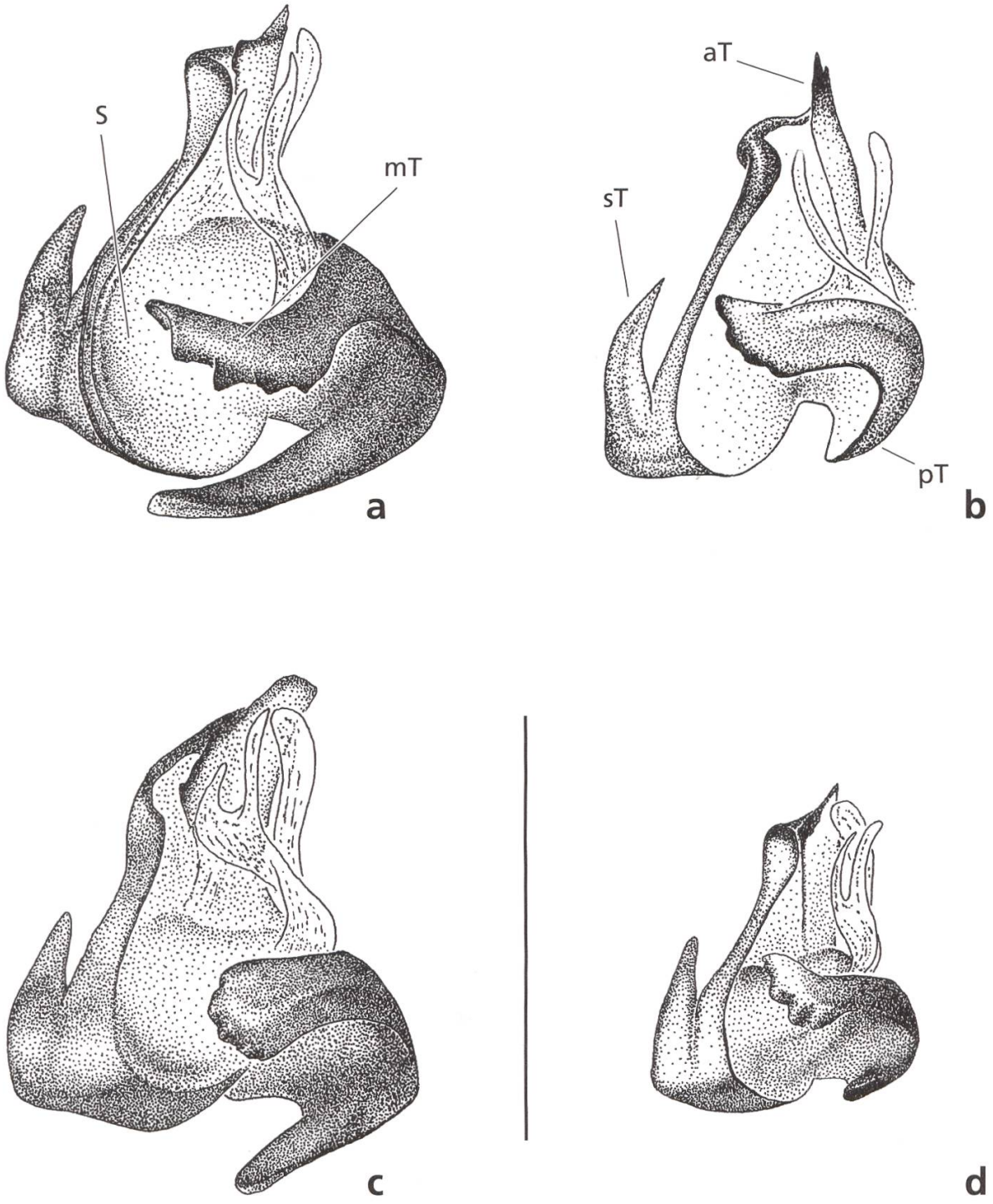

Fig. 3. Male palp, prolateral-ventral view of embolic division. – a: *E. cristatopalpus*; – b: *E. tenuimana*; – c: *E. tirolensis*; – d: *E. aletris*. Scale 0.2 mm. aT = anterior tooth, mT = median tooth, pT = posterior tooth, S = scaphium, sT = scaphium tooth.

Jungfrau to Eggishorn, 2400–2934 m, 1 ♂ 9.–10. 7. 1923, leg. E. Schenkel (NMB 1533a, b – mixed up series with 1 ♂ from Val Bedretto, Ticino) [Schenkel 1925].

Comparative material of *E. aletris* Crosby & Bishop, 1928 (Figs. 1d, 3d):
USA: *New York*. Orient, 72° W 41° N, 1 ♂ 2 ♀ 21. 6. 1934, leg. Crosby & Dietrich (AMNH). *Massachusetts*. Quad, 71° W 42° N, 2 ♂ (AMNH). Lynn, Oak Island, 70°W 42°N, 1 ♂ 30. 4. 1911, leg. J. H. Emerton (AMNH). Ipswich, 70° W 42° N, 4 ♂, leg. J. H. Emerton (AMNH). *Maine*. Lubec, 67° 2' W 44° 50' N, 1 ♂ (AMNH).

Diagnosis: Within the *E. psychrophila* group, *E. tenuimana* shows affinities to both *E. cristatopalpus* and *E. tirolensis*, but it is clearly smaller in the dimensions. Males differ in the rudimentary posterior tooth of the embolic division (Fig. 3b), from *cristatopalpus* they can also be distinguished by their relatively smaller tibial pit (Fig. 1b vs. 1c), from *tirolensis* by the shape of the apophysis-like retrolateral border of the pit (Fig. 1b vs. 1a). Females are characterised by the shape of the lateral and median plates of the vulva (Fig. 4b) and the lack of anteriolateral teeth on the chelicerae (Fig. 4h). For relationships with *E. aletris* Crosby & Bishop, 1928 see remarks.

Male: Carapace: Length 0.84–1.08, width 0.66–0.82, cephalic part clearly elevated, lateral margin with 11–22 relatively small teeth.

Chelicerae (Fig. 4e): Row of anteriolateral tubercles with 4–5 prominent teeth of increasing size (sometimes except the apical one), alongside the fang with 5 promarginal and 4 retromarginal teeth.

Legs: Length of leg I: Fe 0.58–0.98, Pa 0.20–0.24, Ti 0.54–0.70, Mt 0.44–0.54, Ta 0.36–0.44.

Male palp (Figs. 1b, 2b,c, 3b): Fe 0.66–0.82, with 5–6 prolateral knobs or teeth in lateral view. Pt 0.28–0.40, with large, variable apical apophysis. Ti 0.38–0.36, with a large pit on the retrodorsal end reaching less than 1/3 of tibia length, dorsal ridge of the pit with distinct notch, retrolateral border with apophysis-like lanceolate structure, ventral apophysis without tooth. Embolic division with four teeth in the typical arrangement of the *psychrophila* group as defined by Crosby & Bishop (1928). Median tooth with distal ripples, posterior tooth rudimentary, not exceeding half length of median tooth.

Female: Carapace: Length 0.94–1.00, width 0.68–0.76, lateral margin only with hardly appreciable, tiny denticles.

Chelicerae (Fig. 4h): Anteriolateral tubercles existent, but not with prominent teeth; alongside the fang with 5 promarginal and (3–) 4 retromarginal teeth.

Legs: Length of leg I: Fe 0.66–0.72, Pa 0.2–0.23, Ti 0.54–0.62, Mt 0.46–0.52, Ta 0.38–0.44.

Epigyne/vulva (Fig. 4b): Width of scape approximately 0.2 mm, posterior margin rather triangular with notch, weakly sclerotised. Median plate rect-

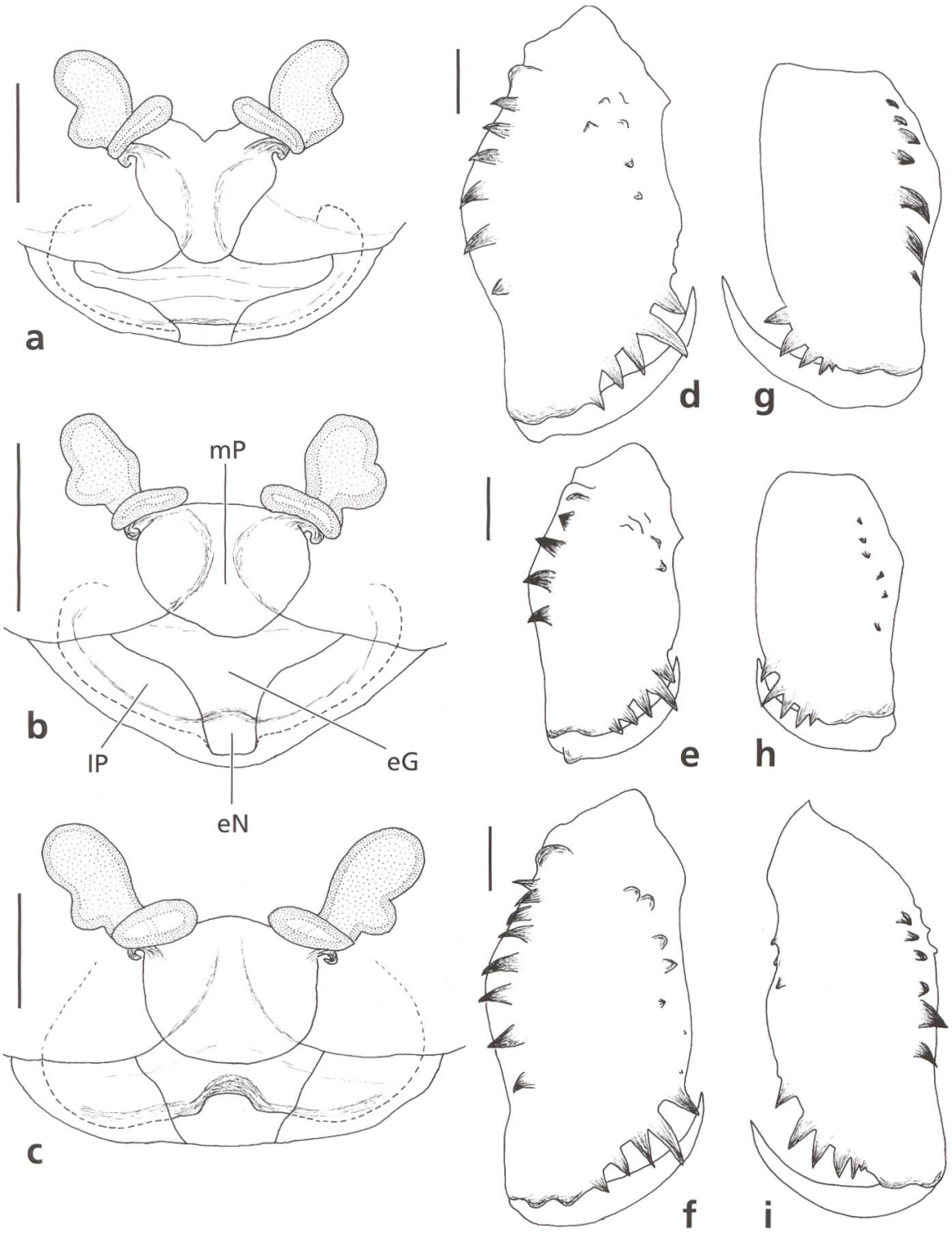

Fig. 4. Vulva, dorsal (a–c), male right chelicera (d–f), female left chelicera (g–i). — a, d, g: *E. cristatopalpus*; — b, e, h: *E. tenuimana*; — c, f, i: *E. tirolensis*. Scale 0.1 mm. eG = epigynal groove, eN = epigynal notch, lP = lateral plates, mP = median plate.

angular. Lateral plates faint, median margins almost parallel before turning outwards. Receptacula widely separated from each other, widest distance between outer margins approximately 0.18 mm. Length of receptacula 0.075 mm.

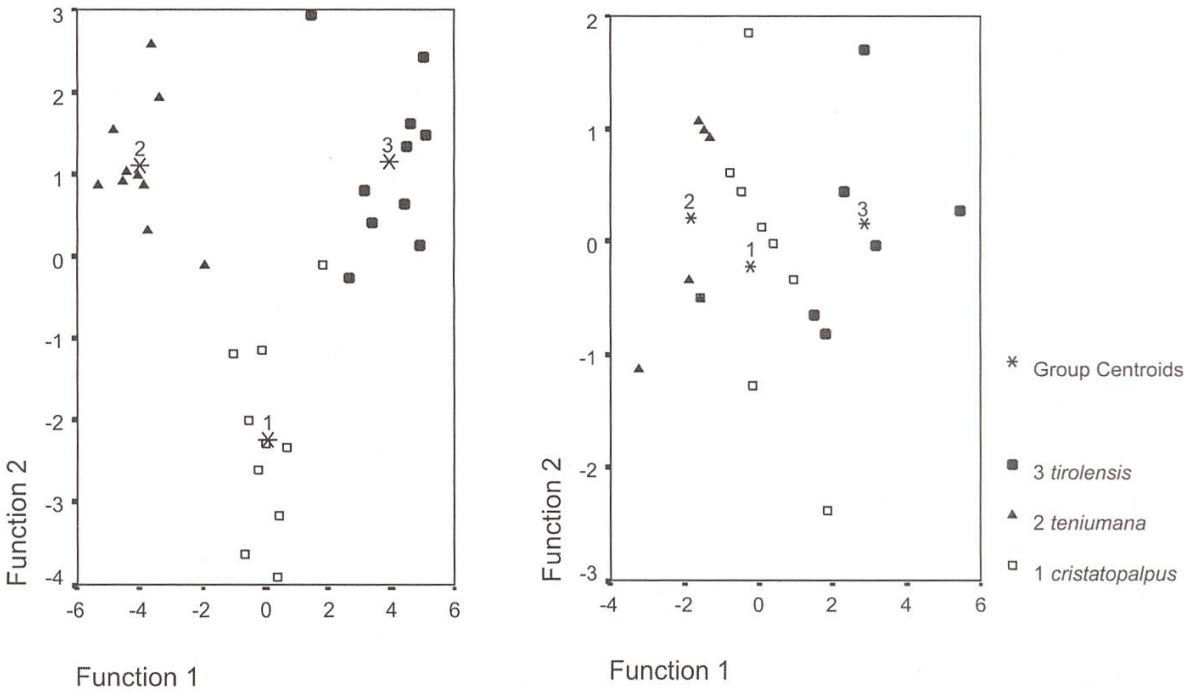

Fig. 5. Scatterplot of individuals along the first two discriminant functions. Left: Males. Eigenvalue of function 1: 11.56 (80.6%), function 2: 2.79 (19.4%). Correlation coefficients with function 1: CyL 0.87, PPt -0.60, FeI 0.52, ChT 0.35; with function 2: CyL -1.14, FeI 0.76, ChT 0.54, PPt 0.48. Right: Females. Eigenvalue of function 1: 3.33 (98.5%), function 2: 0.05 (1.5%). Correlation coefficients with function 1: Mt1 0.88, ChT 0.59; with function 2: ChT 0.81, MtI -0.49.

Remarks: *E. tenuimana*, described by Simon from Faillefeu (Basses Alpes) in the southwestern Alps, has escaped the attention of arachnologists for many decades. To our knowledge, Schenkel (1925, 1929) has been the last to record this species from Bedretto/Tessin and Fiesch/Wallis. In the catalogue of Swiss spiders this species was listed as a doubtful record (Maurer & Hänggi 1990). A strikingly similar species was described from North America by Crosby & Bishop (1928), *E. aletris*. Snazell (1980) published the first record of this species for Europe from Scotland, where the species has been reported from a number of localities in subsequent years. According to Snazell (1980), the only difference would be the existence of a small ventral tooth on the palpal tibia in *E. aletris*. We can confirm that this character is missing in *E. tenuimana* from the Alps, but otherwise we did not find any differences in somatic or genital characters. We doubt the taxonomic value of this character, because first, variation in tibial dentition is common in other species, second, a personal communication by Crawford shows significant character variation among specimens of a North American population from missing to distinct, and third, we examined Nearctic material without such a tooth. However, for the time being we refrain from formal synonymization for the same reasons as with *E. cristatopalpus/zographica*.

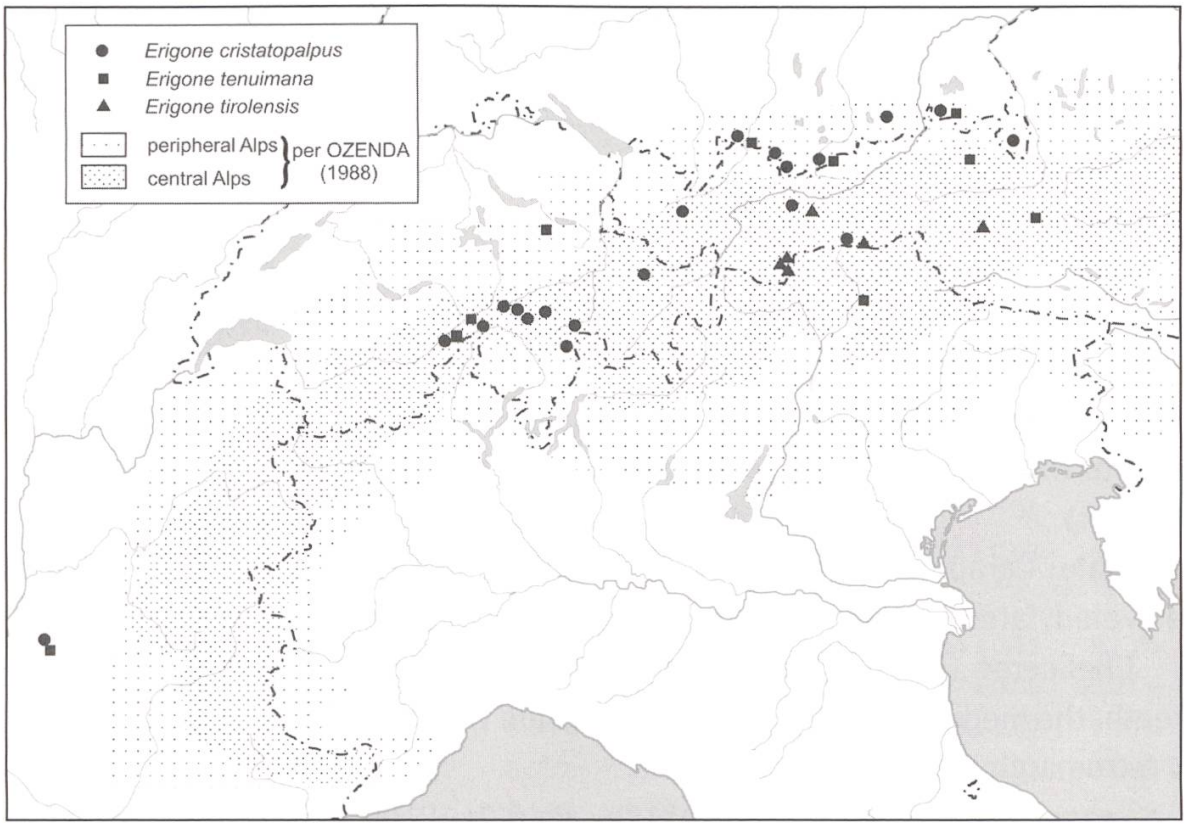

Fig. 6. Verified records of *Erigone cristatopalpus*, *E. tenuimana* and *E. tirolensis* in the Alps.

Distribution: Until we started our investigation, this species had only been recorded from the French Alps (Basses-Alpes, Alpes-Maritimes, Drôme; Simon 1926) and from southern Switzerland (Wallis, Tessin; Schenkel 1925, 1929). The numerous localities which have now become known from the northern margin of the Alps, from the Austrian central Alps and also from the southern calcareous Alps suggest a wide distribution across the whole arc of the Alps (Fig. 6). The preferred habitats are subalpine pastures between 1400 and 2400 m a.s.l. This species seems to be less associated to wet habitats than *E. cristatopalpus*. The two species can be found together.

***Erigone tirolensis* L. Koch, 1872** (Figs. 1c, 3c, 4c, f, i)

E. tirolensis; L. Koch (1872): 277. – see Platnick (2009) for a full list of illustrated references.

Material examined:

AUSTRIA: *Carinthia*. Hohe Tauern. Grossglocknerstrasse, 1900–2580 m, 10 ♂ 29. 7.–15. 9. 1979, 4 ♂ 15. 9.–20. 10. 1979, 23 ♂ 3 ♀ 1978–1980, leg. K. Thaler (MHNG). ♂ *North Tyrol*. Tuxer Alpen. Kraxentrager, 5 ♂ 2 ♀, leg. Janetschek, Steinböck (NMB 323b, ex Coll. E. Schenkel). Ötztaler Alpen.

Niederjochferner, 2 ♀, leg. Steinböck (NMB 323f); Hauslabjoch, 3200 m, 2 ♂ 1 ♀ 28. 8. 2005, leg. C. Muster (CM A1825); Hochwildehaus, 2700–2880 m, 1 ♂ 4 ♀ 15. 8. 2006, leg. C. Muster (CM A1855). Stubaier Alpen. Kirchendachspitze, 2600–2840 m, 1 ♀ 2. 7. 1999, leg. C. Muster (CM A0963).

Diagnosis: Within the *E. psychrophila* group, this species shows affinities to both *E. cristatopalpus* and *E. tenuimana*. The best diagnostic character in the male palp is the broad triangular shape of the apophysis-like retrolateral border of the tibial pit (Fig. 1c). Females can be distinguished from other species of the group by the strongly sclerotised bulge and notch of the epigyne (Fig. 4c).

Male: Carapace: Length 1.14–1.32, width 0.92–1.04, cephalic part clearly elevated, lateral margin with 14–24 large teeth of alternating length.

Chelicerae (Fig. 4f): Row of anteriolateral tubercles with 6–9 prominent teeth, the median ones the largest, alongside the fang with 5 promarginal and 4 retromarginal teeth.

Legs: Length of leg I: Fe 0.90–1.06, Pa 0.24–0.30, Ti 0.74–0.94, Mt 0.66–0.84, Ta 0.50–0.60.

Male palp: (Figs. 1c, 3c): Fe 0.90–1.12, with distal protuberance and 7–12 prolateral knobs or teeth in lateral view. Pt 0.44–0.60, with large, variable apical apophysis. Ti 0.38–0.54, with a large pit on the retrodorsal end reaching less than 1/3 of tibia length, dorsal ridge of the pit with notch, retrolateral border with apophysis-like triangular structure, ventral apophysis without tooth, sometimes with indistinct knob. Embolic division with four teeth in the typical arrangement of the *psychrophila* group as defined by Crosby & Bishop (1928). Median tooth with distal ripples, posterior tooth a distinctive tapering process.

Female: Carapace: Length 1.06–1.36, width 0.78–1.04, lateral margin with denticles.

Chelicerae (Fig. 4i): Row of anteriolateral tubercles with 5–7 short teeth, much smaller than in males; alongside the fang with 5 (–6) promarginal and (3–) 4 retromarginal teeth.

Epigyne/vulva (Fig. 4c): Width of scape approximately 0.38 mm, posterior margin with strongly sclerotised bulge and notch. Median plate rectangular. Lateral plates large and conspicuous, inner margins diagonally diverging. Receptacula widely separated from each other, widest distance between outer margins approximately 0.29 mm, position oblique. Length of receptacula 0.11–0.137 mm.

Remarks: This species was accurately characterized by Thaler (1978) and many other authors. Apparently there has been less confusion as compared with the other two species. However, the "first record for Germany" (Schmidt 1994) refers to *E. tenuimana*. Thus, *E. tirolensis* has to be deleted from the

		cristatopalpus		*tenuimana*		*tirolensis*	
males							
Carapace	length	1.14 ± 0.08	7.03%	0.99 ± 0.07	7.01%	1.23 ± 0.07	5.59%
	width	0.87 ± 0.07	7.78%	0.75 ± 0.05	6.89%	0.97 ± 0.04	3.75%
Male palp	Femur	0.82 ± 0.14	17.21%	0.71 ± 0.11	15.77%	1.04 ± 0.07	6.84%
	Patella	0.41 ± 0.12	28.79%	0.34 ± 0.05	13.65%	0.53 ± 0.06	10.66%
	Tibia	0.40 ± 0.07	17.54%	0.31 ± 0.03	8.74%	0.47 ± 0.05	11.09%
	Cymbium	0.43 ± 0.03	5.88%	0.33 ± 0.02	5.00%	0.47 ± 0.03	5.65%
Leg I	Femur	0.80 ± 0.05	6.73%	0.70 ± 0.04	5.80%	0.99 ± 0.05	5.02%
	Patella	0.25 ± 0.02	8.49%	0.21 ± 0.01	6.96%	0.27 ± 0.02	8.58%
	Tibia	0.71 ± 0.07	9.38%	0.61 ± 0.05	8.32%	0.84 ± 0.07	8.12%
	Metatarsus	0.59 ± 0.05	8.75%	0.50 ± 0.03	5.13%	0.73 v 0.06	7.60%
	Tarsus	0.45 ± 0.03	6.58%	0.41 ± 0.02	5.75%	0.54 ± 0.03	5.51%
females							
Carapace	length	1.08 ± 0.08	7.18%	0.97 ± 0.03	2.66%	1.14 ± 0.11	9.73%
	width	0.83 ± 0.07	7.87%	0.73 ± 0.03	4.10%	0.87 ± 0.09	10.21%
Leg I	Femur	0.79 ± 0.07	8.56%	0.70 ± 0.02	2.84%	0.93 ± 0.09	9.93%
	Patella	0.23 ± 0.02	6.85%	0.21 ± 0.01	5.90%	0.26 ± 0.02	7.66%
	Tibia	0.68 ± 0.06	9.55%	0.59 ± 0.03	4.79%	0.76 ± 0.05	6.77%
	Metatarsus	0.58 ± 0.08	12.98%	0.48 ± 0.02	4.77%	0.72 ± 0.07	9.24%
	Tarsus	0.47 ± 0.03	7.39%	0.41 ± 0.02	5.11%	0.5 ± 0.06	11.07%

Tab. 1. Morphometric measurements of specimens of the *Erigone psychrophila* group in the Alps, given as mean (in mm) ± SD and coefficient of variation (%). N = 10 ♂, 12 ♀ *cristatopalpus*; 10 ♂, 8 ♀ *tenuimana*; 10 ♂, 6 ♀ *tirolensis*.

checklist of German spiders, though it might occur at the highest summits of the Allgäu and Berchtesgaden Alps and in the Wettersteingebirge.

Distribution: Holarctic species with arctic-alpine disjunction. In the Alps, *E. tirolensis* is restricted to high alpine and subnival habitats from 2300–3500 m a.s.l. (Fig. 6). Therefore this species is rare in the northern calcareous Alps as compared to the central Alps (Thaler 1999). There is a clear ecological separation from the other two species, as the records <2600 m come from glacier forelands. We have not observed mixed-up series with the other species.

Morphometric analysis

The data used in the discriminant analysis are given in Tab. 1 with their standard deviation and coefficients of variation. Using the male data set, four variables entered the model significantly: length of femur I (FeI), cymbium (CyL), palpal patella (PPt) and number of cheliceral teeth (ChT). Two canonical discriminant functions were used in the analysis with Eigenvalues of 11.56 (80.6% of vari-

ance explained) and 2.79 (19.4%) (Fig. 5). Cymbium length is most strongly correlated with both canonical functions (correlation coefficient with function 1: 0.87, function 2: -1.14). The most powerful discriminant function for males is:

D = -23.85 + 37.9 CyL + 10.83 FeI – 7.43 PPt +0.46 ChT.

Using this model, 96.7% of the males were correctly classified.

With the female data set, only two variables entered the model significantly: length of metatarsus I (MtI) and number of cheliceral teeth (ChT). The Eigenvalues of the first two canonical functions are 3.33 (98.5%) and 0.05 (1.5%) (Fig. 5). Function 1 is most strongly correlated with metatarsus length (correlation coefficient 0.89), function 2 with number of cheliceral teeth (0.81). The most powerful discriminant function for females is:

D = -12.29 + 14.34 MtI + 0.81 ChT.

Using this model, 88.5% of the females were correctly classified.

Discussion

The longlasting confusion of the three species of the *E. psychrophila* group in the Alps is a result of their close similarity in somatic and genitalic characters, the high degree of intraspecific variation and their syntopic occurrence at some localities. In our opinion, the structure of the male palpal tibia, the embolic division and the shape of the median and lateral plates of the epigyne/vulva are the most reliable characters for species discrimination. Furthermore we found that the species differ significantly in their dimensions. *Erigone tenuimana* is by far the smallest species, while *tirolensis* is slightly larger than *cristatopalpus*. There is relatively little overlap, especially in cymbium length, which is 0.30–0.36 in *E. tenuimana*, 0.38–0.46 in *cristatopalpus* and 0.40–0.50 in *tirolensis*. Generally, females are slightly smaller than the corresponding males, but the differences between species are less obvious. This is reflected in the results of the discriminant analysis, which is mainly based on characters related to body size, where the males are much better separated (Fig. 5). While females of *E. tirolensis* are easy to recognize by the heavily sclerotised rim of the epigyne, the separation of females of the remaining two species is more tricky. The identification of the females of *E. cristatopalpus* and *tenuimana* was complicated by the fact that a series of males from the Simon collection was accompanied by a single female of *E. cristatopalpus*, and by the misleading illustration of a "*cristatipalpus*" vulva in Thaler (1978: fig. 25), which in fact shows *E. tenuimana*. Only the kind loan of large series from the Bavarian Alps by D. Leipold allowed us to reveal the true

identity of the *tenuimana* female. In addition to genital differences, we found the dentition of the anteriolateral margin of the chelicerae to be a good discriminating character. Although the number of tubercles in this row is on average even higher in *E. tenuimana* than in *cristatopalpus*, *E. tenuimana* lacks any prominent teeth. On the other hand, females of the other two species have at least some teeth similar in size to those of the males (Figs. 4d–i). This seemed to be a constant feature among all populations investigated, although it should be noted that in general dentition of carapace, chelicerae and palpal segments is highly variable within species. Asymmetric development of left and right chelicerae is also commonly observed. This casts doubt on the use of teeth and protuberances on certain segments of the male palp for species discrimination. Moreover, the relative length of the segments of the male palp, also suggested to be of taxonomic relevance (e. g. Crosby & Bishop 1928), is exceptionally variable, as already noted by Roberts (1987: 95). This is seen in the high coefficients of variation, which are 2–3 times higher than those of the leg segments (Tab. 1). Given this high degree of plasticity and the transatlantic distribution of many *Erigone* species, we are rather sure that *E. aletris* and *zographica* will eventually turn out to be junior synonyms of *E. tenuimana* and *cristatopalpus*, respectively. We fully agree with Snazell (1980) who wrote "it seems possible that several more synonymies may exist within the *psychrophila* group, described by Crosby & Bishop and later added to by other authors..." This author faced the same problem as we did – the paucity of material from widely separated areas.

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