

***Georthocladius chastreixens* and *G. digitiformis* spp. n., from springs and peat bogs in continental France [Diptera, Chironomidae, Orthoclaadiinae]**

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Male adult of *Georthocladius* (*G.*) *chastreixens* sp. n. and *G.* (*G.*) *digitiformis* sp. n. is described based on material recently collected in acidic and non-acidic springs and peat bogs of continental France. The first species is only known from mountains (Chastreix-Sancy, Massif central, alt. 1300 m), the second occurs in both mountains and lower wetlands areas (Massif central and north eastern areas, alt. 250-1420 m). Based on some atypical characters, *G. chastreixens* sp. n. appears to belong to a separate group of species, while *G. digitiformis* sp. n. keys directly close to *G. collarti* (Goetghebuer, 1942). Main distinguishing characters are: -in *G. chastreixens* sp. n. (antenna without apical seta, AR 1.31; clypeus shield shaped; palpomere 3 with spatulate sensilla coeloconica; humeral pit bare; tergites I-VI spotted; distal part of sternite VIII rectangular; virga absent; anal point broadly wide, median part semicircular, expanded laterally; inferior volsella bilobed, proximal lobe smaller, distal lobe vertical rectangle-like; gonostylus triangular, lateral and caudal margins concave, apex with a robust spine, crista dorsalis absent); -in *G. digitiformis* sp. n. (antenna with 1-2 pre-apical setae, AR 0.91; clypeus trapezoidal; humeral pit with unusual dark spots; tergites not spotted; anal point triangular, with ventral expansion; sternapodeme rounded; virga vertical comma shaped; inferior volsella elongate, distinctly digitiform, with rounded apex; gonostylus triangular, lateral and posterior margins convex, posterior part rounded, bare with a pre-apical robust spine, crista dorsalis absent). Currently, the genus *Georthocladius* subgenus *Georthocladius* is represented by four species in Europe: *G. collarti*, *G. meluensis* Moubayed-Breil, 2020, *G. techensis* Moubayed-Breil, 2020 and *G. retezati* (Albu, 1972). Only the first three species were reported from France. Consequently, the discovery of *G. chastreixens* sp. n. and *G. digitiformis* sp. n. increases the total number of known species to five from this country. Three of the associated species are new for the French fauna: *Chaetocladus subalpinus* Rossaro, Magoga & Montagna, 2017; *Lasiodiamesa sphagnicola* (Kieffer, 1925) and *Cricotopus magus* Hirvenoja, 1973. Taxonomic remarks and comments on the ecology and geographical distribution of the new species are given.

***Georthocladius chastreixens* et *G. digitiformis* spp. n. connus de sources et tourbières de France continentale (Diptera, Chironomidae, Orthoclaadiinae)**

Mots-Clés: *Georthocladius chastreixens* sp. n., *G. digitiformis* sp. n., description, adulte mâle, France continentale, conservation.

L'adulte mâle de *Georthocladius* (*G.*) *chastreixens* sp. n. et de *G.* (*G.*) *digitiformis* sp. n. est décrit à partir d'un matériel récemment collecté dans des sources et tourbières acides et non-acides de France continentale. La première est uniquement connue de montagne (Chastreix-Sancy, Massif-Central, alt. 1300 m), la seconde, de montagne et d'habitats situés à des altitudes inférieures (Massif central, Ardenne, Vosges, alt. 250-1420 m). Sur la base de certains caractères atypiques, *G. chastreixens* sp. n. semble appartenir à un nouveau groupe d'espèces, alors que *G. digitiformis* sp. n. se place près de *G. collarti* (Goetghebuer, 1942). Les principaux

caractères distinctifs sont : - *G. chastreixens* sp. n. (antenne sans soie apicale; clypéus en forme de bouclier; palpomère 3 muni de sensilla coeloconica spatulés; huméral pit glabre ; tergites I-VI munis de spots; partie distale du sternite VIII rectangulaire ; pointe anale très large, partie médiane semi-circulaire, étendue latéralement ; volselle inférieure bilobée, lobe proximal plus petit, lobe distal rectangulaire; gonostyle triangulaire, côtés latéral et caudal concaves, apex muni d'une épine robuste, crista dorsalis absente); - *G. digitiformis* sp. n. (antenne muni de 1-2 soies pré-apicales; clypéus trapézoïdal ; creux huméral avec des granulations noirâtres ; tergites sans spots ; pointe anale triangulaire, munie d'une expansion ventrale ; volselle inférieure digitiforme, apex arrondi; gonostyle triangulaire, marges latérale et caudale convexes, bout postérieur arrondi, muni d'une épine pré-apicale robuste, crista dorsalis absente). Jusqu'à présent quatre espèces étaient représentées en Europe : *G. collarti*, *G. meluensis* Moubayed-Breil, 2020 ; *G. techensis* Moubayed-Breil, 2020 et *G. retezati* (Albu, 1972) dont seules les trois premières sont signalées de France. La découverte de *G. chastreixens* et de *G. digitiformis* spp. n. porte à six le total des espèces connues de ce pays. Trois des espèces associées sont nouvelles pour la faune de France : *Chaetocladius subalpinus* Rossaro, Magoga & Montagna, 2017; *Lasiodiamesa sphagnicola* (Kieffer, 1925) et *Cricotopus magus* Hirvenoja, 1973. Un commentaire sur la position systématique, l'écologie et la distribution géographique des deux nouvelles espèces est fourni.

1. Introduction

Data on the taxonomy, geographical distribution and ecology of known species belonging to the genus *Geothocladius* Strenzke, 1941 (GOETGHEBUER 1940, 1941, STRENZKE 1941, ALBU 1972, SÆTHER & SUBLETTE 1983, CRANSTON & OLIVER 1988, CRANSTON et al. 1989, TATOLE 1999, LANGTON & PINDER 2007, ASHE & O'CONNOR 2012, SÆTHER & SPIES 2013, MOUBAYED-BREIL & ASHE 2016, MAGOGA et al. 2017, NAMAYANDEH et al. 2020, MOUBAYED-BREIL 2020, MOUBAYED & LANGTON 2022) show that there are currently four known species from Europe: *G. collarti* (Goetghebuer, 1941), *G. meluensis* Moubayed-Breil, 2020; *G. techensis* Moubayed-Breil, 2020 and *G. retezati* Albu (1972). Large investigations recently implemented between 2016 and 2023 in cold acidic and non-acidic springs and peat bogs located in mountainous and lowland areas of both central and north eastern areas of continental France, revealed the presence of two yet undescribed species namely: *G. chastreixens* sp. n. and *G. digitiformis* sp. n. The first species occurs in mountainous habitats, the second in both mountains and lowland areas.

In this paper, a detailed morphological description of the male adult of *G. chastreixens* sp. n. and *G. digitiformis* sp. n. is provided. Taxonomic remarks, differential diagnosis and comments on the geographical distribution and ecology of the two new species are given.

2. Material and methods

The studied material is composed of male and female adults collected by G. Coppa in two regions of continental France: National Nature Reserve of Chastreix-Sancy (central area) and both of the Ardennes and Vosges departments (north eastern areas). The used sampling methods are: sweep entomological net (for adults) and Brundin drift nets (for embedded adults, pupae, pupal exuviae and larvae). The examined adults were preserved in 80-85% ethanol for taxonomic observation and description. Information on the methodology of mounting and conservation of the type material is provided in MOUBAYED-BREIL & ASHE (2015). Morphological terminology and measurements follow that of SÆTHER (1980) for the imagines.

3. Descriptions

Georthocladius chastreixens sp. n.

Holotype. Continental France. 1 male adult (leg. G. Coppa), National Nature Reserve of Chastreix-Sancy (NNRCS, Central France); tributary of the River Gagne, para-peaty bogs (Photo 1); downstream ‘Buron du Roc de Tuile’; 45° 30’ 47” N, 2° 46’ 49” E; alt. 1292 m; 06.IV.2017. Environmental data of water: T°C minima 0-6, maxima 10-12 °C; Conductivity around 60 µS/cm; pH nearly neuter.

Paratypes (all leg. G. Coppa). 7 male adults, same type-locality and date as for holotype. Mounted adults (5 males); unmounted adults (2 males, preserved in 80% ethanol).

Holotype, male adult mounted on one slide, and one paratype are deposited in the collections of the ‘Musée cantonal de Zoologie, Palais de Rumine, 6 place de la Riponne, CH-1014 Lausanne (MZL), Switzerland’. Remaining paratypes are deposited in the collection of the author.

Etymology: the new species is named ‘*chastreixens*’ after the Nature Reserve of Chastreix-Sancy, which covers cold springs, streams, peat and para-peaty bogs, where the type-material was collected.



Photo 1. Type-locality of *G. chastreixens* sp. n. (holotype and paratype). Tributary of the River Gagne flowing in para-peaty bogs (alt. ≈1300 m), NNR of Chastreix-Sancy (T. Leroy, 13.X.2023).

Photo 1. Localité-type de *G. chastreixens* sp. n. (holotype et paratype). Affluent de la Gagne traversant des prairies para-tourbeuses (alt. ≈ 1300 m), RNN Chastreix-Sancy (Cliché T. Leroy, 13.X.2023).

Diagnostic characters

G. chastreixens sp. n. is easily separated from other members of the genus *Georthocladius* by the following distinctive characters. Antenna without apical seta, terminal segment 475 µm long, AR 0.92; clypeus shield shaped. Lobes of antepnotum not gaping; humeral pit bare; scutellum with 6 setae. Anal lobe of wing low, not protruding, squama with 9-10 setae. Legs. Sensilla chaetica present on tibia and tarsomeres ta₁-ta₅. Tergites I-VI with a characteristic caudal spot; tergite IX widely expanded laterally into 2 large lateral lobes; sternite IX rectangular distally, markedly

overreaching apex of anal point; virga absent; anal point broadly wide, basal part with a dark sinuous transverse band, typically expanded laterally, apex semicircular; posterior margin with 30-32 fine setae; inferior volsella distinctly double, dorsal lobe, vertically bilobed, proximal lobe smaller, distal lobe elongate, nearly rectangular; ventral lobe low lobe shaped. Gonostylus triangular, atypically shaped in acute position, covered with curved setae, lateral and caudal margins distinctly concave; anterior side with numerous needle-like setae; posterior side with a robust apical spine, ending with a rounded pubescent lobe; crista dorsalis absent.

Male adult

(n = 6; Figs 1A-P; Photos 2A-B)

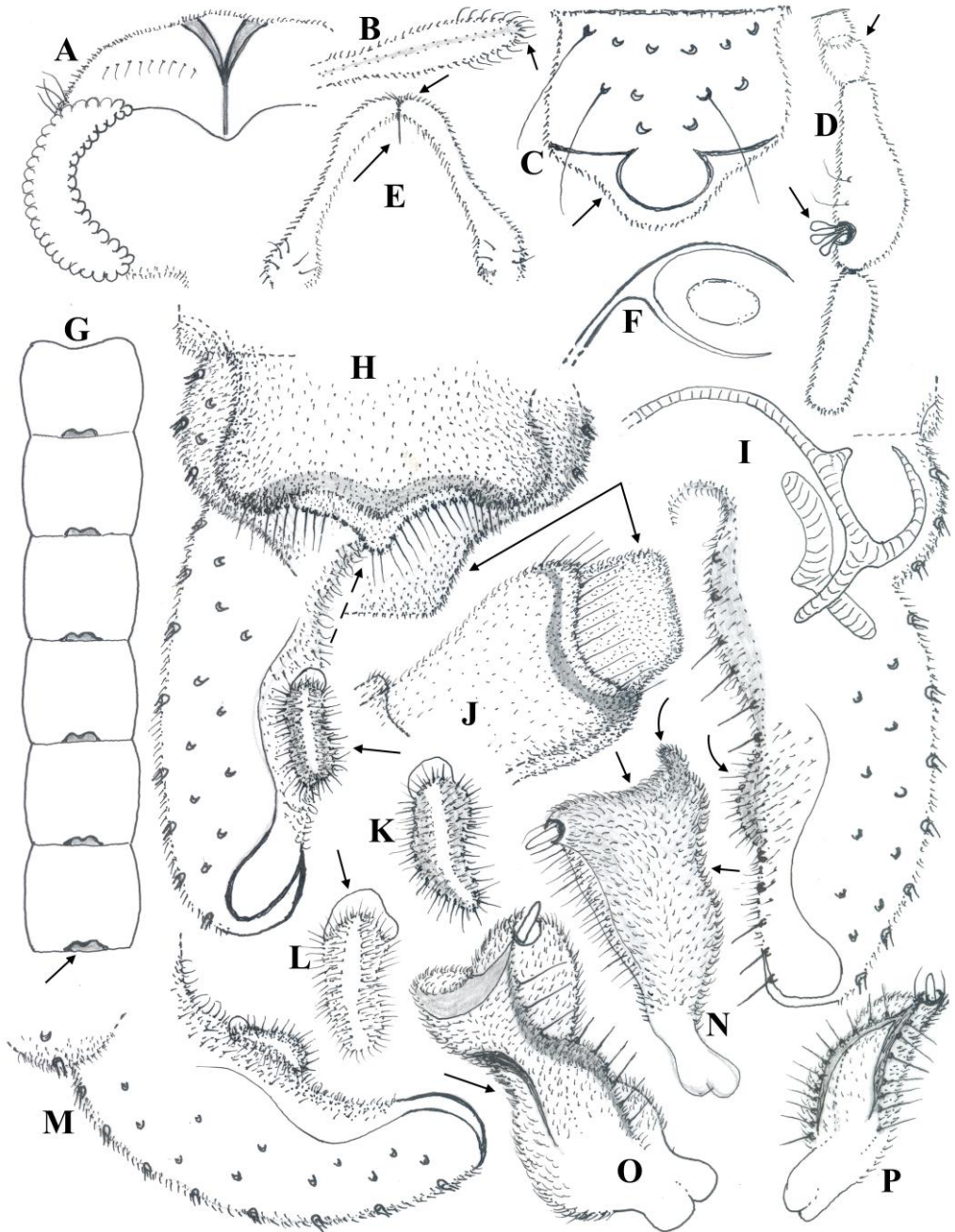
Total length 3.15 mm. Wing length 2.20 mm, TL/WL = 1.41. General colouration contrasting brownish to blackish. Head dark brown; antenna brownish; thorax contrasting brown to dark brown, mesonotal stripes dark brown; wing pale; legs brown to dark brown; abdomen brownish, anal segment contrasting dark brown to blackish. Head (left side, Fig. 1A). Eyes bare; frontal tubercle absent, coronal suture thick; temporals 14 including 9 inner (uniserial) and 4 outer verticals, postorbitals absent. Antenna 985 μm long, last flagellomere (Fig. 1B) 475 μm long, linearly elongate, weakly clubbed with numerous curved sensilla chaetica, apical seta absent, antennal groove beginning at segment 2, AR 0.92. Clypeus (Fig. 1C) shield shaped, with 12 setae in 3 rows. Palp 5-segmented, palpomeres 1-4 (Fig. 1D), segments 1-2 fused, palpomere 3 with 2 sensilla clavata and 3 spatulate sensilla coeloconica, segment 4 rectangular; length (μm) of palpomeres: 25, 50, 135, 115, 345. Thorax. Lobes of anteprenotum (Fig. 1E), not gaping, lateral anteprenotals 5; basal midline of scutum with a characteristic thin band; acrostichals 14 in 1-2 rows, located close to anteprenotum; dorsocentrals 20-21 in 1-2 rows, all decumbent; prealars 6 uniserial; humeral pit ovoid, without granulation; scutellum with 6 setae in 1 row (3 on each side of the midline); preepisternum bare. Wing. Wide 630 μm ; brachiolum with 1 seta; subcosta overreaching the fork of radius, costal expansion absent; anal lobe low, not projecting; number of setae on veins: R, 16-17; R₁, 6-8; R₄₊₅, 3 located distally; remaining veins bare; squama with 9-10 setae. Legs. Sensilla chaetica abundant on tibia and ta₁- ta₅ of PI-PIII; length of tibial spurs: PI, 75 μm long; PII, 55 and 45; PIII 70 and 60. Length (in μm) and proportions of prothoracic (PI), mesothoracic (PII) and metathoracic (PIII) legs as in the following table:

	fe	ti	ta ₁	ta ₂	ta ₃	ta ₄	ta ₅	LR	BV	SV	BR
PI	1113	1150	790	465	350	210	140	0,69	2,62	2,86	1113
PII	1060	1095	495	330	240	145	115	0,45	3,19	4,35	1060
PIII	1180	1305	710	390	310	185	140	0,54	3,12	3,50	1180

“LR = Length of tarsomere ta₁ divided by length of tibia (ti); BV = Combined length of femur (fe), tibia and ta₁ divided by combined length of tarsomeres ta₂-ta₅; SV = Ratio of femur plus tibia to tarsomere ta₁; BR = Ratio of longest seta of ta₁ divided by minimum width of ta₁, measured one third from apex.”

P.79. Figure 1. Male adult of *Georthocladius chastreixens* sp. n. Head, left side (A); apical part of antenna (B); clypeus (C); palpomeres 1-4 (D); lobes of anteprenotum (E); humeral area (F); tergites I-VI (G); hypopygium, dorsal (H) and ventral (I); tergite IX and anal point, lateral (J); inferior volsella, two aspects (K-L); gonocoxite and inferior volsella, lateral (M); gonostylus, lateral (N), at acute angle (O-P). The arrows indicate some distinctive characters.

P.79. Figure 1. Adulte mâle de *Georthocladius chastreixens* sp. n. Tête, côté gauche (A); partie apicale de l'antenne (B); clypéus (C); palpomères 1-4 (D); lobes de l'antépronotum (E); aire humérale (F); tergites I-VI (G); hypopyge en vue dorsale (H) et ventrale (I); tergite IX et pointe anale, vue latérale (J); volselle inférieure, deux aspects (K-L); gonocoxite et volselle inférieure, vue latérale (M); gonostyle, vue latérale (N) et à angle aigu (O-P). Les flèches indiquent quelques caractères distinctifs.



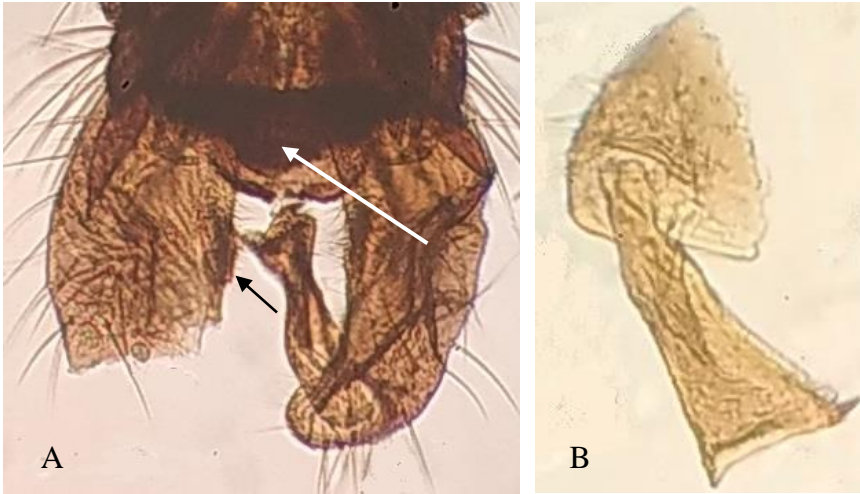


Photo 2. *G. chastreixens* sp. n. Hypopygium, dorsal (A) with 2 arrows showing the anal point and inferior volsella; gonostylus (B) at obtuse angle.

Photo 2. *G. chastreixens* sp. n. Hypopyge en vue dorsale (A) avec deux flèches montrant la pointe anale et la volselle inférieure; gonostyle (B), angle obtus.

Hypopygium. Dorsal and ventral view as in Figs 1H-I and Photo 2A (Fig. 1H, Photo 2A dorsal; Fig. 1I, ventral with tergite IX and anal point omitted). Tergite IX 100 μm long, 185 μm maximum width, posterior half broadly expanded laterally giving appearance of 2 large specific lateral lobes. Anal point (Fig. 1H, Photo 2A, dorsal; Fig. 1J, lateral) 30 μm long, 175 μm maximum width at base, typically expanded laterally, basal part dark, with a distinct transverse sinuous band, apex semicircular; entire lateral and posterior margins with 30-32 needle-like setae. Sternite IX (Figs 1H, J; Photo 2A) broadly rectangular distally, distinctly overreaching apex of anal point (by 65-70 μm); latero-sternite IX with 10 setae (5 on each side). Sternapodeme and phallapodeme (Fig. 1I), transverse sternapodeme well-developed, rounded, orally projecting; phallapodeme half sickle-like, basal part inwardly directed, elongate and rounded. Virga absent. Gonocoxite (Figs 1H-I, M) 310 μm long; dorsal side linearly elongate; ventral side widely swelling proximally, margin with 13 stout inner setae. Inferior volsella (Figs 1H, K-M, Photo 2A, dorsal; Fig. 1M, lateral) 55-60 μm long, 25 μm maximum width, distinctly double, densely covered with short setae; dorsal lobe, vertically bilobed, proximal lobe smaller, bare; distal lobe kidney to bean shaped (occasionally rectangular); ventral lobe about 50 μm long, low lobe-like shaped. Gonostylus as in Figs 1N-P and Photos 2A-B (Figs 1O-P, Photo 2A, acute angle; Fig. 1N, lateral; Photo 2B, obtuse angle), 175 μm long, 50 μm maximum width, slender in its proximal half, becoming massive and widely expanded distally; atypically shaped at acute triangle; lateral and posterior margins markedly concave (Figs 1N-O; Photos 2A-B); anterior side with numerous needle-like setae (Figs 1O-P), posterior side ending into a robust spine (Fig. 1N; Photo 2B); pre-apical anterior part (Figs 1O-P; Photo 2A) rounded to lobe-like when viewed at acute angle (Figs 1O-P; Photo 2A), densely covered with curved short blackish setae; crista dorsalis absent; megaseta (Figs 1N-P; Photos 2A-B) slender and pointed, located apically, clearly visible dorsally at acute, right angle and lateral view. HR = 1.77; HV = 1.80.

Female adult: known but not described. **Pupal exuviae and larva:** unknown.

Georthocladius digitiformis sp. n.

Holotype. Continental France. 1 male adult (leg. G. Coppa), Givonne (French Ardennes department, NE-France); Ruisseau des Fraichis (Photo 4), acidic spring and peat bogs; Bois de Woaygnie; 49° 44' 31" N, 4° 59' 48" E; alt 278 m; 04.IV.2023. Environmental data of water surface are: Conductivity 0 to 5 μ S/cm; T °C minima 2-6, maxima 8-12; pH 5-6.

Paratypes (all leg. G. Coppa). 11 adults, same type-locality and date as for holotype. 12 male adults, Le Châtelet-sur-Sormonne (Ardennes department), Biological Reserve of Bérulle; ditch near "Étang de la Passee"; 49° 52' 11" N, 04° 31' 28" E; alt. 351 m. 5 male adults, La Bresse (Vosges dpt, NE-France), acidic springs and peat bogs of Machais Nature Reserve; 48° 00' 15" N, 06° 57' 51" E; alt. 982 m; 03.V.2022; crystalline water, Cd 6-16 μ S/cm; T °C 1-4 during late winter and spring; pH acid 3-5. 17 male adults, Chastreix-Sancy NNR (Puy-de-Dôme dpt); alt. 1150-1420 m; 21.X.2016, 06.IV.2017.

Holotype, male adult mounted on one slide, and one paratype are deposited in the collections of the 'Musée cantonal de Zoologie, Palais de Rumine, 6 place de la Riponne, CH-1014 Lausanne (MZL), Switzerland'. Remaining paratypes are deposited in the collection of the author.

Etymology: the name '*digitiformis*' of the new species refers to the shape of the inferior volsella, which is distinctly elongate and digitiform shaped.



Photo 3. Type-locality of *G. digitiformis* sp. n. (holotype and paratype). Acidic spring and peat bogs of 'Ruisseau des Fraichis', Givonne, Ardennes department (G. Coppa, 18.IV.2023).

Photo 3. Localité de *G. digitiformis* sp. n. (holotype et paratype). Ruisseau des Fraichis et tourbières acides, Givonne, département des Ardennes (Cliché G. Coppa, 18.IV.2023).

Diagnostic characters

G. digitiformis sp. n. and *G. collarti* (Goetghebuer, 1942) are closely related based on some common relevant features found in their male adult. However, the new species is easily separated by the following combination of characters. Median tubercle of vertex triangular; antenna 830 μ m

long, last segment 470 μm long, with 1-2 pre-apical setae, AR 1.31; clypeus semicircular, with 11 setae; palpomere 3 with 3 digitiform sensilla coeloconica. Lobes of antepronotum well gaping; scutum with a characteristic vertical band; humeral pit covered with dense blackish granulations; scutellum with 20-22 setae in 3 rows. Anal lobe of wing protruding at right angle, squama with 23-25. Tibia and tarsomeres $\text{ta}_1\text{-ta}_5$ of PI-PIII with numerous sensilla chaetica. Tergites I-VIII without spots; tergite IX semicircular; sternite VIII projecting caudally; virga vertical comma shaped; anal point broadly triangular, with 28-30 curved stout setae, ventral side with a typical rounded expansion. Gonocoxite with a characteristic linear swelling on distal part; superior volsella low; inferior volsella digitiform, with 2 interrupted groups of small dorsal setae. Gonostylus triangular, lateral and caudal margins distinctly convex; anterior side with numerous needle-like setae; posterior side with a robust apical spine, ending with a rounded bare lobe; crista dorsalis absent.

Male adult

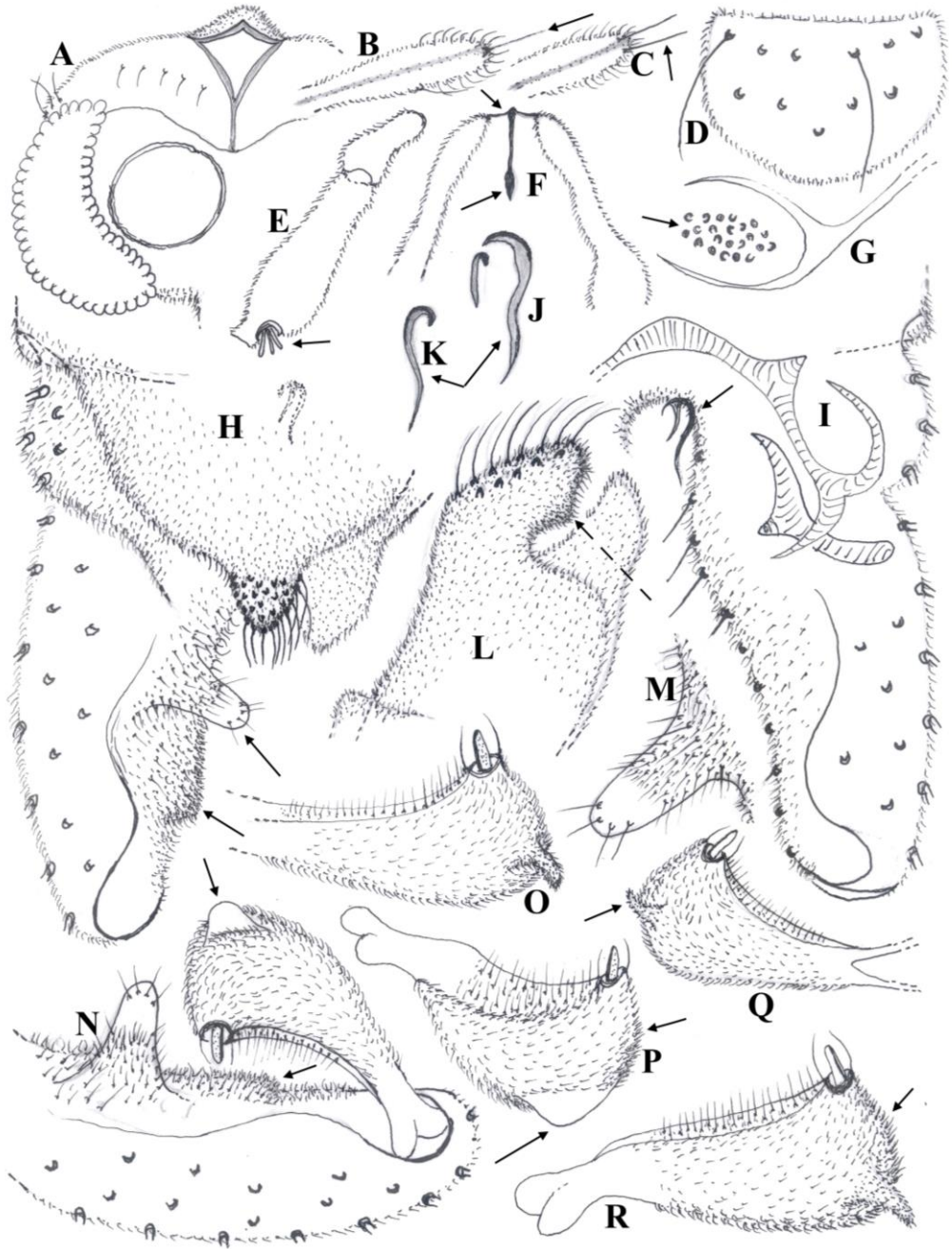
(n = 11; Figs 2A-R; Photos 4A-B)

Total length 3.10 mm. Wing length 2.20 mm, TL/WL = 1.41. General colouration contrasting brownish to blackish. Head dark brown; antenna brownish; thorax contrasting brown to blackish, mesonotal stripes dark brown; halteres blackish, wing pale; legs brown to dark brown; abdomen brownish, anal segment contrasting dark brown to blackish.

Head (left side, Fig. 2A). Eyes bare; frontal tubercle well-developed, triangular, coronal suture thin; temporals 8 including 5 inner uniserial and 3 outer verticals, postorbitals absent. Antenna 830 μm long, last flagellomere (Figs 2B-C) 470 μm long, weakly clubbed, bearing numerous sensilla chaetica and 1-2 apical setae; antennal groove beginning at segment 2, AR 1.31. Clypeus (Fig. 2D) semicircular, 60 μm long, 100 μm maximum width, with 11 setae, in 3 rows. Palp 5-segmented, segments 1-3 fused, segments 4 and 5 rectangular; palpomeres 2-3 (Fig. 2E), segment 3 with 3 stick-like sensilla coeloconica, sensilla clavata absent; segments 3 and 4 subequal; length (μm) of palpomeres 1-5: 20, 50, 100, 105, 125. Thorax. Lobes of antepronotum (Fig. 2F), typically widely gaping, lateral antepronotals 5; scutum with a characteristic thick sclerotized band at its basal midline; acrostichals 15-17 in 1-2 rows, located a short distance from the antepronotum; dorsocentrals 19-20 in 1-2 rows, all decumbent; prealars 7 in 1 row; humeral pit ovoid, covered with specific blackish granulations; scutellum with 20-22 setae in 3 rows; preepisternum bare. Wing. Maximum width 570 μm ; brachiolum with 1 seta; subcosta overreaching the fork of radius, costal expansion absent; anal lobe well developed, projecting at right angle; number of setae on veins: R, 16; R_1 , 10; R_{4+5} , 8-9 (occasionally, only 3 located at apically); remaining veins bare; squama with 23-25 setae in 1-2 rows.

P. 83. Figure 2. Male adult of *Georthocladius digitiformis* sp. n. Head, left side (A); apical part of antenna (B-C); clypeus (D); palpomeres 1-2 (E); lobes of antepronotum (F); humeral area (G); hypopygium in dorsal (H) and ventral view (I); virga (J-K); tergite IX and anal point, lateral (L); inferior volsella (M); gonocoxite and inferior volsella, lateral (N); gonostylus, different aspects (N-R). The arrows indicate some distinctive characters.

P. 83. Figure 2. Adulte mâle de *Georthocladius digitiformis* sp. n. Tête, côté gauche (A); partie apicale de l'antenne (B-C); clypéus (D); palpomères 1-2 (E); lobes de l'antépronotum (F); creux huméral (G); hypopyge, vues dorsale (H) et ventrale (I); virga (K-J); tergite IX et pointe anale, vue latérale (L); volselle inférieure (M); gonocoxite et volselle inférieure, vue latérale (N); gonostyle, différents aspects (N-R). Les flèches indiquent quelques caractères distinctifs.



Legs. Sensilla chaetica abundant on tibia and ta_1 - ta_5 of PI-PIII; length of tibial spurs: PI, 75 μ m long; PII, 55 and 45; PIII 70 and 60. Length (in μ m) and proportions of prothoracic (PI), mesothoracic (PII) and metathoracic (PIII) legs as in the following table:

	fe	ti	ta ₁	ta ₂	ta ₃	ta ₄	ta ₅	LR	BV	SV	BR
PI	1090	1070	865	455	390	225	150	0,81	2,48	2,50	1090
PII	1110	1040	530	300	240	160	160	0,51	3,12	4,06	1110
PIII	1195	1230	735	425	50	215	180	0,60	2,70	3,30	1195



Photo 4. *G. digitiformis* sp. n. Hypopygium: (A), dorsal. Arrows indicate the inferior volsella and the swelling of gonocoxite; (B), lateral. Arrow indicates the ventral expansion of anal point.

Photo 4. *G. digitiformis* sp. n. Hypopyge: (A), vue dorsale. Les flèches montrent la volselle inférieure et le renflement du gonocoxite; (B), vue latérale. La flèche montre l'expansion ventrale de la pointe anale.

Hypopygium in dorsal and ventral view (Figs 2H-I, Photos 4A-B; Fig. 2H, Photo 4A, dorsal; Fig. 2I, ventral; Photo 4B, lateral). Tergite IX (Fig. 2H, dorsal; Fig. 2L, lateral) 110 μ m long, 180-200 μ m maximum width, broadly semi-circular in its posterior distal half. Anal point (Fig. 2H, dorsal; Fig. 2L, Photo 4B, lateral) 60 μ m long, 80-85 μ m maximum width at base, broadly triangular with rounded apex (occasionally acute triangle shaped), bearing about 28-30 stout curved setae of 30-35 μ m long; ventral side with a characteristic rounded expansion (Fig. 2L, Photo 4b). Sternite IX broadly triangular distally, overreaching apex of anal point; latero-sternite IX with 10 setae (5 on each side). Sternapodeme phallapodeme and virga as in Fig. 2I; transverse sternapodeme weakly projecting orally, thicker medially; coxapodeme short; phallapodeme nearly sickle-like. Virgal spines (Figs 2H-K) vertical long-comma shaped, well-sclerotized, fused to base of gonocoxite. Gonocoxite (Fig. 2H, dorsal; Fig. 2I, ventral; Fig. 2N, lateral) 275 μ m long, 135-140 μ m maximum width; distal part of dorsal margin bearing a specific elongate swelling (visible in Fig. 2H, Photo 4A); ventral margin with 11 stout inner setae. Inferior volsella (Figs 2H, M, dorsal; Fig. 2N, lateral) 50 μ m long, 25 μ m maximum width; distinctly digitiform, with 2 groups of interrupted short setae; apical part with 4 setae. Gonostylus in different aspects (Figs 2N-R, Photos 4A) 125 μ m long, 60 μ m maximum width, broadly triangular, slender in its proximal half, massive and widely expanded distally; lateral and posterior margins convex (Figs 2N-R); anterior side with numerous needle-like setae, posterior side ending into a robust spine (Figs 2O, Q, R); posterior part rounded, distinctly bare (Figs 2N, P); crista dorsalis absent. Megaseta slender, mainly visible in dorsal and lateral view, not visible at acute angle (Photo 4A, right side). HR = 2.20; HV = 2.48.

Female adult, pupal exuviae and larva: known but not described.

4. Differential diagnosis

Actually, the genus *Georthocladius* is represented by four species in Europe: *G. collarti*, *G. meluensis*, *G. techensis* and *G. retezati*. Among them, only the first three species were reported from France. Consequently, the discovery of *G. chastreixens* sp. n. and *G. digitiformis* sp. n. increases the total number of known species to five from this country.

Some unusual morphological characters found in the male adult of *G. chastreixens* sp. n. (spatulate sensilla coeloconica present on palpomere 3; humeral pit present but bare; tergites I-VI markedly spotted caudally; posterior half of tergite IX well-expanded laterally; anal point widely extended laterally, apex rounded; sternite IX strongly overreaching tip of anal point; virga absent; inferior volsella double, dorsal lobe bilobed, ventral lobe low; gonostylus with lateral and posterior margins concave, acute angle atypically shaped), it appears to belong to a separate group of species. In the other hand, on the basis of some similar morphological characters between *G. digitiformis* sp. n. and both of *G. collarti* and *G. retezati*, the three latter species appear to belong to one and same group of *Georthocladius* species.

The main distinguishing characters found in the male adult of the two new species are summarized in the following differential diagnosis.

G. chastreixens sp. n.

- Antenna without apical seta, AR 1.31;

- Clypeus shield shaped; palpomere 3 with spatulate sensilla coeloconica; humeral pit bare; tergites I-VI spotted caudally; distal part of sternite VIII rectangular; transverse sternapodeme rounded; virga absent; anal point broadly wide, expanded laterally, apical part semicircular; inferior volsella bilobed, proximal lobe smaller and bare, distal lobe rectangular, densely covered with short setae; gonostylus triangular, lateral and caudal margins concave, apex with a robust spine, typically shaped at acute angle, crista dorsalis absent.

G. digitiformis sp. n.

Morphological differences between *G. digitiformis* sp. n. and similar European congeners (namely: *G. collarti* and *G. retezati*) are highlighted in the following combination of characters.

- Antenna with 1-2 pre-apical setae, AR 0.91;

- Clypeus trapezoidal; humeral pit with atypical small blackish granulation; tergites not spotted; virga vertical long-comma shaped; anal point with ventral expansion; inferior volsella distinctly digitiform, apex rounded; gonostylus triangular, lateral and posterior margins convex, posterior part rounded, bare with a pre-apical robust spine, crista dorsalis absent.

At present, it is not feasible to provide a definitive key to known male adult until sufficient material (composed of adults, pupae and larvae of all species) has been examined and compared. However, a provisional key to known male adult of *Georthocladius* from Europe is given below.

Key to known male adult of *Georthocladius* (*G.*) from Europe

1. Anal point concave, widely extended transversally, with decumbent setae (MOUBAYED-BREIL 2020, Figs. 2H, K); gonostylus L-shaped (MOUBAYED-BREIL 2020, Figs. 2L-M), with pre-apical spines..... *G. techensis*

- Anal point broadly elongate, triangular, sub-rectangular or widely expanded laterally, without decumbent setae; gonostylus without pre-apical spines..... 2

2. Gonostylus linearly elongate; megaseta inserted dorsally; anal point sub-rectangular; inferior volsella simple, broad lobe-like, bearing stout curved setae (MOUBAYED-BREIL 2020, Figs 1I, L)..... *G. meluensis*
- Gonostylus triangular, massive distally (Figs 1N, 2N-R; Photos 2B, 4A); megaseta inserted dorsally or ventrally; anal point triangular, ventral expansion absent; inferior volsella double or simple; antenna with or without apical seta..... 3
3. Inferior volsella double, dorsal lobe bilobed (Figs 1H, K-M); antenna without apical seta; tergites I-VI spotted caudally (Fig. 1G); anal point not triangular, widely expanded (Fig. 1H; Photo 2A), without ventral expansion; latero-sternite rectangular, strongly overreaching tip of anal point (Figs 1H, J; Photo 2A); virga absent; crista dorsalis absent, megaseta inserted dorsally (Figs 1N-P; Photos 2A-B)..... *G. chastreixens* sp. n.
- Inferior volsella simple, rectangular or digitiform; antenna with or without apical setae; anal point triangular (Fig. 1H; Photo 4A), with or without ventral expansion; latero-sternite triangular, weakly overreaching tip of anal point (Fig. 1H); virga present or absent; megaseta inserted dorsally or ventrally..... 4
4. Gonostylus without posterior expansion, crista dorsalis absent; megaseta located ventrally; inferior volsella rectangular, with truncate apex; antenna without apical seta; humeral pit bare; virga present (MOUBAYED & LANGTON 2022, Figs 1H-M) *G. collarti*
- Gonostylus with rounded posterior expansion, crista dorsalis present; megaseta located dorsally; inferior volsella not rectangular, apex pointed; antenna without apical seta; virga absent (ALBU 1972, Fig. 3; TATOLE 1999, Fig. 1B)..... *G. retezati*
- Gonostylus with pointed posterior expansion (Figs 2O, Q-R), crista dorsalis absent (Figs 2O, Q-R), megaseta located dorso-ventrally (Figs 2N-R, dorsal view; Photo 4A, right and left sides); inferior volsella digitiform, apex rounded (Figs 2H, M-N; Photo 4A); antenna with 1-2 apical setae (Figs 2B-C); humeral pit with blackish granulation (Fig. 2G); anal point with a distinct ventral expansion (Fig. 2L; Photo 4B); virga present (Figs 2H-K)..... *G. digitiformis* sp. n.

5. Ecology and geographical distribution

Larval populations of the genus *Georthocladius* include both semi-lentic and lentic species mainly occurring in cold acidic and non-acidic springs, streams, peat and para-peaty bogs enriched with emerged and submerged aquatic plants and mud substrata. Therefore, both *G. chastreixens* sp. n. and *G. digitiformis* sp. n. appear to belong to the crenophilous community of species as documented by LINDEGAARD (1995). Localities, where the type-material of the two species was collected (Photos 1, 3), consist of pristine aquatic habitats, actually endangered by pollution and various perturbation caused by human activities. The latter aquatic habitats are considered to be microrefugia and hotspots of diversity and therefore deserve much greater consideration, protection and preservation.

G. chastreixens sp. n. was captured only as male and female adults from mountainous habitats located in the NNR of Chastreix-Sancy (alt. about 1300 m; Photo 1), while an abundant material composed of adults (males and female), pupae, pupal exuviae and larvae of *G. digitiformis* sp. n. was obtained in both mountains and lower wetlands areas (central and north eastern areas of France, alt. 250-1420 m).

Geographical distribution of *G. chastreixens* sp. n. is actually restricted to mountainous areas situated in central areas of continental France. *G. digitiformis* sp. n., in particular, seems to be more widely distributed and therefore, can be expected to occur in other similar mountainous and lower wetlands areas situated in France and other European countries: Belgium, Switzerland, Italy, Spain, Germany, Austria, Poland, Romania. Nevertheless, as reported below, a higher specific richness is record in springs, peat and para-peaty bogs of Chastreix-Sancy.

Emergence recorded in mountainous acidic and non-acidic habitats (NNR of Chastreix-Sancy): during late spring and autumn (May-June and September-October) for both *G. chastreixens* sp. n. and *G. digitiformis* sp. n. In lower wetlands mainly covered by acidic springs and peat bogs (Ardennes and Vosges regions, NE-France), the emergence of *G. digitiformis* sp. n. is recorded only during the early spring season (March-April).

Encountered chironomid species in the same type-localities as for the two new species are separately reported here for the first time from the NNR of Chastreix-Sancy and the Ardennes region. Species indicated by an asterisk (*) are new record for France.

- Associated species with *G. chastreixens* sp. n. are: *Paraboreochlus minutissimus* (Strobl, 1895); *Cardiocladius fuscus* Kieffer, 1924; *Chaetocladius laminatus* Brundin, 1947; *C. subalpinus* Rossaro, Magoga & Montagna, 2017*; *C. suecicus* (Kieffer, 1916); *Cricotopus C. algarum* (Kieffer, 1911); *C. fuscus* (Kieffer, 1909); *Gymnometriocnemus kamimegavirgus* Sasa & Hirabayshi, 1993; *Limnophyes cranstoni* Sæther, 1990; *L. pentaplasatus* (Kieffer, 1921); *L. gelasinus* Sæther, 1990; *Metriocnemus albolineatus* Meigen, 1818; *M. eurynotus* (Holmgren, 1883); *M. fuscipes* (Meigen, 1818); *M. tristellus* Edwards, 1929; *Pseudorthocladius cranstoni* Sæther & Sublette, 1983; *Symbiocladius rhithrogenae* (Zavrel, 1924); *Micropsectra roseiventris* Kieffer, 1909; *M. recurvata* Goetghebuer, 1928; *Tanytarsus palettaris* Verneaux, 1969.

- Associated species with *G. digitiformis* sp. n. are: *Lasiodiamesa sphagnicola* (Kieffer, 1925)*; *Cricotopus fuscus*; *C. magus* Hirvenoja, 1973*; *Gymnometriocnemus kamimegavirgus*; *G. brumalis* (Edwards, 1929); *Heleniella ornatcollis* (Edwards, 1929); *Limnophyes cranstoni*; *L. pentaplasatus*; *L. gelasinus*; *Metriocnemus albolineatus*; *M. eurynotus*; *M. fuscipes*; *Pseudorthocladius cranstoni*; *Micropsectra roseiventris*; *M. schrankelae* Stur & Ekrem, 2006; *Tanytarsus debilis* (Meigen, 1830); *T. sylvaticus* (van der Wulp, 1859).

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References

- ALBU, P. 1972. Două specii de Chironomidae noi pentru știință în masivul Retezat. *Studii și Cercetări de Biologie, Série de Zoologie*, **24** (1): 15-20.
- ASHE, P. & J.P. O'CONNOR. 2012. *A World Catalogue of Chironomidae (Diptera). Part 2. Orthoclaadiinae*. Irish Biogeographical Society & National Museum of Ireland, Dublin. 968 pp.
- CRANSTON, P.S., D.R. OLIVER & O.A. SÆTHER. 1989. The adult males of Orthoclaadiinae (Diptera, Chironomidae) of the Holarctic Region - Keys and diagnoses. In: Wiederholm, T. (ed.): Chironomidae of the Holarctic region. Keys and diagnoses. Part 3-Adult males. *Entomologica Scandinavica, Supplement*, **34**: 164-352.

- GOETGHEBUER, M. 1940. Chironomides de Laponie Suédoise. *Bulletin et Annales de la Société Entomologique de Belgique*, **80** (1): 55-72.
- GOETGHEBUER, M. 1941. Notes sur la faune des Hautes-Fagnes en Belgique. V. Diptera: Chironomidae, Ceratopogonidae. *Bulletin du Musée Royal d'Histoire Naturelle de Belgique*, **17** (67): 1-12.
- LANGTON, P.H. & L.C.V. PINDER. 2007. *Keys to the adult males of Chironomidae of Britain and Ireland*. Volume **1** (Pp 1-239) and volume **2** (Pp 1-168). Freshwater Biological Association, Scientific Publication, n° **64**.
- LINDEGAARD, C. 1995. Chironomidae (Diptera) of European cold springs and factors influencing their distribution. *Journal of the Kansas Entomological Society, Supplement* **68** (2): 108-131.
- MAGOGA, G., M. MONTANA, L. MARZIALI & B. ROSSARO. 2017. Revision of type and non-type material assigned to the genus *Orthocladius* by Goetghebuer (1940–1950), deposited in the Royal Belgian Institute of Natural Sciences (Diptera, Chironomidae). *Acta Entomologica Musei Nationalis Pragae*, **57** (2): 723-749.
- MOUBAYED, J & P.H. LANGTON. 2022. Redescription of the type specimens of *Georthocladius* (*Georthocladius*) *collarti* (Goet., 1941) and *Parachaetocladius scaturiginis* (Goet., 1940) n. comb., with keys to the European species (Diptera, Chironomidae). *Ephemera*, **23** (1): 11-21.
- MOUBAYED-BREIL, J. 2020. *Georthocladius meluensis* and *G. techensis* (Diptera, Chironomidae, Orthoclaadiinae), two new relict species inhabiting glacial springs and streams in Corsica and Eastern Pyrenees. *Annales Zoologici Fennici*, **57**: 215-223.
- MOUBAYED-BREIL, J. & P. ASHE. 2015. *Eukiefferiella brulini* sp. n., a commensal species on *Ancylus fluviatilis* Müller, occurring in the Mediterranean coastal ecosystem of continental France (Diptera, Chironomidae, Orthoclaadiinae). *Ephemera*, **15** (2): 79-92.
- NAMAYANDEH, A., J. MOUBAYED, E. GHADERI & D. BERESFORD. 2020. Review of the genera *Georthocladius* Strenzke, 1941 and *Parachaetocladius* Wülker, 1959 (Chironomidae, Orthoclaadiinae): new species descriptions, and keys based on morphological characters of adult male. *Polish Journal of Entomology*, **90** (2): 59-80.
- SÆTHER, O.A. 1980. Glossary of chironomid morphology terminology (Diptera, Chironomidae). *Entomologica Scandinavica*, **14**: 1-51.
- SÆTHER, O.A. & J.E. SUBLETTE. 1983. A review of the genera *Doithrix* n. gen., *Georthocladius* Strenzke, *Parachaetocladius* Wülker, and *Pseudorthocladius* Goetghebuer (Diptera, Chironomidae, Orthoclaadiinae). *Entomologica Scandinavica Supplements*, **20**: 1-100.
- STRENZKE, K. 1941. Terrestrische Chironomiden. X. *Georthocladius luteicornis* Goetgh. (Mit einem Beitrag von Dr. M. Goetghebuer, Gent.). *Zoologischer Anzeiger*, **135** (9/10): 177-185.
- TATOLE, V. 1999. *Georthocladius retezati* (Albu, 1972) comb. nov. syn. *Parachaetocladius retezati* Albu, 1972 (Diptera, Chironomidae). *Travaux du Muséum national d'histoire naturelle "Grigore Antipa"*, **41**: 331–335.