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On the genus *Bryophaenocladius* Thienemann, 1934. I. Taxonomic notes with description of new species (Diptera: Chironomidae, Orthocladiinae)

О роде *Bryophaenocladius* Thienemann, 1934. I. Таксономические замечания с описанием новых видов (Diptera: Chironomidae, Orthocladiinae)

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Abstract. Taxonomic notes on the genus *Bryophaenocladius* Thienemann, 1934 are given based on a material recently collected along a large latitudinal gradient in Europe (Switzerland, continental France, Corsica, Italy, Spain) and North-Africa (Algeria, Morocco). Four new species, *Bryophaenocladius bedumonti* Moubayed, **sp.n.**, *B. helveticus* Moubayed et Lods-Crozet, **sp.n.**, *B. tyrrhenius* Moubayed, **sp.n.** and *B. vernensis* Moubayed, **sp.n.**, are diagnosed and described. *B. bedumonti* Moubayed, **sp.n.** is described as male adult and pupal exuviae while the three remaining species are described only as male adult. A combination of some unusual distinctive characters found in the male adult (shape of the anal point, inferior volsella and gonostylus), both *B. bedumonti* Moubayed, **sp.n.** and *B. helveticus* Moubayed et Lods-Crozet, **sp.n.** are considered as local biogeographical element, while *B. tyrrhenius* Moubayed, **sp.n.** and *B. vernensis* Moubayed, **sp.n.** show some morphological similarity with *B. furcatus* (Kieffer, 1916), *B. muscicola* (Kieffer, 1906), *B. nidorum* (Edwards, 1929), *B. scanicus* Brundin, 1947 and *B. tuberculatus* (Edwards, 1929). Currently, the genus comprises about 80 known species from the Palaearctic Region, of which 33 are reported from Europe. Consequently the description of the four new species increases the total number in the genus to 37 valid species from this region. Taxonomic remarks related to the generic diagnosis are also provided, which complement some previous data from the literature. Discussion, differential diagnosis and comments on the ecology and geographical distribution of the four new species are given.

Резюме. В работе на основе материала, недавно собранного в Европе: Швейцарии, континентальной Франции, Корсике, Италии и Испании, и Северной Африке: Алжире и Марокко, обобщены сведения о таксономии рода *Bryophaenocladius* Thienemann, 1934. Описано четыре новых вида: *Bryophaenocladius bedumonti* Moubayed, **sp.n.**, *B. helveticus* Moubayed et Lods-Crozet, **sp.n.**, *B. tyrrhenius* Moubayed, **sp.n.** и *B. vernensis* Moubayed, **sp.n.**, из которых *B. bedumonti* Moubayed, **sp.n.** описан по имаго самцу и экзувию куколки, а три других вида — лишь по имаго самцу. Сочетание ряда отличительных признаков: формы анального отростка, нижней волселлы и гоностиля, обнаруженных у взрослых самцов *B. bedumonti* Moubayed, **sp.n.** и *B. helveticus* Moubayed et Lods-Crozet, **sp.n.**, могут рассматриваться как проявление биогеографической специфики морфологии видов. Виды *B. tyrrhenius* Moubayed, **sp.n.** и *B. vernensis* Moubayed, **sp.n.** обнаруживают некоторое морфологическое сходство с *B. furcatus* (Kieffer, 1916), *B. muscicola* (Kieffer, 1906), *B. nidorum* (Edwards, 1929), *B. scanicus* Brundin, 1947 и *B. tuberculatus* (Edwards, 1929). В настоящее время род включает около 80 известных видов из Палеарктики, из которых 33 зарегистрированы в Европе. Следовательно, описание четырёх новых видов увеличивает их общее количество в роде до 37 видов из этого региона. Также приводятся таксономические замечания, относящиеся к общему диагнозу рода, обсуждение, дифференциальный диагноз и комментарии по экологии и географическому распространению новых видов.

Introduction

The male adults of most *Bryophaenocladius* species can be recognized by the shape of tergite IX, the anal point, virga, apodemes, and gonostylus. A large material recently collected along a large latitudinal gradient in Europe, Switzerland, continental France, Corsica, Italy, Spain, and North-Africa, Algeria, Morocco, reveals the presence of four new species, *B. bedumonti* Moubayed, sp.n., *B. helveticus* Moubayed et Lods-Crozet, sp.n., *B. tyrrhenius* Moubayed, sp.n. and *B. vernensis* Moubayed, sp.n., which are described and diagnosed. A diagnosis of the genus is emended whith complements previous data from the literature as documented in Brundin [1947, 1956], Sæther [1973], Caspers, Reiss [1987], Coffman et al. [1986], Cranston, Armitage [1988], Armitage [1987], Cranston et

al. [1989], Willassen [1996], Andersen, Schnell [2000], Kaczorowska, Gilka [2002], Makarchenko, Makarchenko [2006], Wang et al. [2001, 2006], Langton, Pinder [2007a, b], Ding et al. [2011], Donato [2011], Ashe, O'Connor [2012], Sæther, Spies [2013]. In this paper, *B. bedumonti* Moubayed, sp.n. is described as male adult and pupal exuviae, while the other three new species, *B. helveticus* Moubayed et Lods-Crozet, sp.n., *B. tyrrhenius* Moubayed, sp.n. and *B. vernensis* Moubayed, sp.n., are described only as male adult. Taxonomic remarks on related *Bryophaenocladius* species, with comments on the ecology and geographical distribution of the new species are given.

Material and methods

The examined material were collected using sweep and drift nets, then preserved in 80–85 % ethanol and cleared of musculature in 90 % lactic acid (head, thorax, abdomen and anal segment) for about 60 to 80 minutes; this could then be left overnight at room temperature without any detrimental effect or damage. The specimens were checked under a binocular microscope after 20 minutes to determine how the clearing was progressing. When clearing was complete, the specimens were washed in two changes of 70 % ethanol to ensure that all traces of lactic acid were removed. The studied material was mounted in polyvinyl lactophenol. Before the final slide mountings in dorsal view, the hypopygium including tergite IX and anal point, the gonocoxite and the gonostylus, were viewed ventrally and laterally, in order to examine and draw all the necessary details of the species, from both sides. For a better examination of the specific features and more accurate description of the male adult, various taxonomic details in particular, the hypopygium was illustrated in a lateral view separately, when anal point and tergite IX were removed, thus facilitating a proper illustration of some relevant taxonomic characters. Remaining part of the abdomen and the halters are preserved in 85–90 % ethanol for an eventual DNA analysis. Morphological terminology and measurements follow those of Sæther [1980] and Langton & Pinder [2007a, b] for the imagines and Sæther [1980] and Langton [1991] for the pupal exuviae.

Holotypes (male adult, on 1 slide) of the new species are deposited in the collections of the Musée cantonal de Zoologie, Palais de Rumine, 6 place de la Riponne, Lausanne, Switzerland (MZL), paratypes also in the collection of J. Moubayed, Montpellier, France (MCF).

Generic diagnosis for known male adults of the genus *Bryophaenocladius* Thienemann, 1934 from southern Europe and North-Africa

As reported by Wang et al. [2006], the genus *Bryophaenocladius* is one of the more enigmatic orthoclad genera. Therefore, in the following taxonomic notes a combination of some relevant characters related to the male adult (shape of tergite IX, anal point, virga, inferior volsella, apodemes, and gonostylus) are highlighted. A generic provisional diagnosis is also emended, which complements previous data from the literature as documented in Cranston et al. [1989], Wang et al. [2001, 2006], Langton, Pinder [2007a, b], Donato [2011] and Ding et al. [2011]. However, for a better comprehensive knowledge and more reliable taxonomic discussion some relevant distinguishing features are provided, which can be summarised by the following combination of characters.

Head. Frontal tubercles present or absent; inner verticals often inserted on 1 or 2 rows; clypeus broadly sub-rectangular to sub-trapezoidal; palpomere 3 with or without apical projection.

Thorax. Antepronotum well-developed, lobes gaping or fused, occasionally sinuous; acrostichals often decumbent and biserial, consist of robust long setae beginning close to anterior margin of scutum. Humeral pit present or absent. Legs with sensilla chaetica on tibiae and tarsomeres ta_1–ta_5.

Abdomen. Tergite IX semi-circular to sub-rectangular, broad or narrowed distally; dorsal hump present or absent; anal tergite bands present or absent; sclerotized lateral margins often reach basal angle of segment IV, (occasionally interrupted at base of anal point). Anal point broadly to narrowed triangle-like with pointed or rounded apex, lateral expansions short or very long (occasionally absent); dorsal setae mainly stout, in high to low number (dorsal area entirely or partly covered with microtrichia. Virga present or absent, when present it consists of short to long spines. Sternapodeme often semicircular, oral projection low to strong; lateral expansion low (occasionally strong). Phallapodeme well-developed, basal expansion pointed or spatulate, curved inwardly, or occasionally straight, median and apical parts hyaline or strongly sclerotized; aedeagal lobe widely expanded (large plate-like) or narrowed medially. Gonocoxite with truncate or rounded apex; basal junction with or without pars ventralis (ventral lobe); dorsal and ventral inner sides with or without dense sclerotization; superior volsella strongly to weakly swollen. Inferior volsella with 1 or 2 lobes, anterior lobe digitiform, lobe-like, sub-triangular to sub-rectangular, posterior lobe well to weakly-developed (easily overlooked); apical part projecting inwards or downwards (occasionally inwardly turned over) with or without setae on both dorsal and ventral side; inner part of gonocoxite with a characteristic 'setiferous dorsal area', which consists of a group of short setae located around the inferior volsella (proximally, behind or posteriorly). Gonostylus well-developed in general, often broadened or linearly elongate, anterior side with numerous setae, posterior part often hyaline and bare; crista dorsalis present or absent, when present it consists of a large lobe occupying the entire anterior side; megaseta well-developed.

Description of new species

Bryophaenocladius bedumonti Moubayed, **sp.n.**

Figs 1–11, 24–33.

http://zoobank.org/NomenclaturalActs/50D74D28-E4FA-41EC-B9F4-431EDD998D93

= *Bryophaenocladius* sp.1: Moubayed-Breil, Ashe [2016]

Material. **France:** Holotype, ♂ pharate adult, karstic spring, upper basin of Verne stream, Var Department (SE-France), h~400 m a.s.l., 43°25'0" N, 6°47'0" E, 24.V.2005, leg. J. Moubayed (MZL). Environmental data of water: calcareous water, conductivity about 430 µS/cm; temperature 8–12 °C. Paratypes: 1♂ adult + 1♂ pupal exuviae, same locality and data as for holotype (MZL); 1♂ adult, Valescure karstic springs and stream, upper basin of the Real Collobrier River, h~350 m a.s.l., Var Department (SE-France); 43°26'0" N, 6°47'0" E, 24.V.2005, leg. J. Moubayed (MCF).

Etymology. This species is named *bedumonti* in honour of our colleague Bernard Dumont, who remains one of the ardent protectors of the biodiversity in southern France and Alpine Region. Despite his recent retirement, he never stops working as entomologist in contributing to preserve the quality of aquatic habitats and their faunal communities.

Diagnostic characters. Male adult and pupal exuviae of *B. bedumonti* Moubayed, sp.n. can be distinguished from all members of the genus *Bryophaenocladius* by a combination of characters.

Male adult. Head. Temporals 11 (8 inner and 3 outer verticals); antenna 850 µm, AR 0.81; clypeus trapezoidal, with 17 setae; palpomere 3 without apical projection. *Thorax.* Lobes of antepronotum not gaping; acrostichals 14 in 1–2 rows; dorsocentrals 12; prealars 4, scutellum with 8 setae. *Wing.* Squama with 6 setae. *Abdomen*. Tergite IX wider basally and narrowing distally, lacking anal lateral tergite band. Virga absent. Anal point broadly triangular with 1 seta (occasionally 3), without lateral expansions, basal margin without sclerotization. Sternapodeme markedly projecting orally, lateral expansion pointed apically. Phallpodeme slender, aedeagal lobe weak and slightly swollen. Gonocoxite with truncate apex, basal junction bearing a characteristic 'pars-ventralis' ventral lobe; inferior volsella nose-like shaped, distal part marsupial pouch-like lobe; proximal and median parts of setiferous inner area is covered with setae. Gonostylus linearly elongate, posterior tip not projecting; crista dorsalis large low lobe-like, widely expanded.

Pupal exuviae. A combination of some characters found in the pupal exuviae of *B. bedumonti* Moubayed, sp.n. shows a close morphological similarity with that of *B. furcatus*, *B. nidorum*, and *B. subvernalis* (Edwards,1929) as documented in Pankratova [1970] and Langton [1991]. Frontal apotome with wrinkles, anterior part of thorax partly spinulated, antepronotals consist of 3 setae (one long and 2 shorter); thoracic horn absent; precorneals consist of 1 thick (35 µm long) and 2 thinner (25 µm long) long setae; dorsocentrals sub-equal in size with equal distance between Dc_1, Dc_2 and Dc_3. Abdomen belongs to *Bryophaenocladius*-type; tergite I with 2 anteromedian groups of points; anal lobe well-expanded distally, macrosetae absent; genital sac sub-rectangular, not reaching tip of anal lobe.

Male adult of this new species is easily separated from all other related congeners, namely *B. muscicola* (Kieffer, 1906), *B. nidorum*, B. *scanicus* and *B. tuberculatus*, by the presence of a pars-ventralis, which represents an atypical generic character in the genus *Bryophaenocladius*. However, other relevant differentiating characters are also observed: tergite IX without anal tergite bands (Fig. 5); anal point large lobe-like shaped bearing 1 single setae (occasionally 3), lacking sclerotization at base; virga absent; inferior volsella atypically shaped. In *male pupal exuviae B. nidorum* has a nearly similar anal lobe as figured in Pankratova [1970, Figs 149: 6–7], the genital sac and precorneal setae (Figs 14–15, 16) are differently shaped in *B. bedumonti* Moubayed, sp.n. However, the following combination of characters found in the pupal exuviae of *B. bedumonti* Moubayed, sp.n. will easily separate this new species from other related congeners, namely *B. nidorum*, *B. nitidicollis* (Goetghebuer, 1913) and *B. subvernalis*: chaetotaxy of thorax including antepronotals, precorneals and dorsocentrals; shape of anal segment which is markedly expanded distally and lacking macrosetae.

Description. *Male adult.* Small sized species. Total length 2.45–2.55 mm. Wing length 1.45–1.50 mm. General colouration contrasting pale brown to dark brown to blackish. Head, thorax and apodemes dark brown to blackish; abdomen including anal segment contrasting pale to blackish.

Head. Eyes bare. Temporals 11 including 8 inner and 3 outer verticals, inner verticals placed in 2 rows. Antenna 850 µm long, 13-segmented, last flagellomere 380 µm long, AR 0.81; antennal groove beginning on segment 3. Palp 5-segmented; palpomere 3 (Fig. 1) with 3 sensilla clavata. Clypeus sub-trapezoidal, with 17 setae in 3 rows. *Thorax*. Antepronotum well developed, antepronotal lobes not gaping, lateral antepronotals 5; acrostichals 14 in 1–2 rows, starting close to antepronotum; dorsocentrals 12 in 1 row; prealars 4 uniserial; supraalars absent; scutellum with 8 uniserial setae. Humeral pit sub-oval and bearing contrasting small spots. *Wing*. Brachiolum with 1 seta; subcosta reaching fork of radius. Distribution of setae on veins: R, 0–1; R_1, 1–2; remaining veins bare; squama with 6 setae. *Legs*. Tibial spur of PI (Fig. 4) 75 µm long, distinctly curved distally; tibial spurs of PII–PIII 40–50 and 20–25 µm long. Sensilla chaetica present on: tibia and tarsomeres ta_1–ta_5 of PI; tibia and tarsomeres ta_1–ta_4 of PII–PIII. Length (in µm) and proportions of prothoracic (PI), mesothoracic (PII) and metathoracic (PIII) legs as in Table 1. *Abdomen*. Hypopygium in dorsal and ventral view as in Figs 5–6; ventral view (Fig. 6) with tergite IX and anal point removed. Tergite IX broadly sub-rectangular at base, narrowing distally, anal lateral tergite band atypically absent. Anal point (Fig. 5, dorsal; Fig. 7, lateral) about 30–35 µm long, large drop-like shaped; with 1 seta located apically in holotype (occasionally 1–3 setae in paratypes); basal sclerotization absent. Virga absent. Transverse sternapodeme well projecting orally, pointed at base, lateral sternapodeme typically short, lateral expansion pointed. Phallapodeme slender with a weak aedeagal lobe. Gono-

Figs 1–11. Male adult of *Bryophaenocladius bedumonti* Moubayed, sp.n. (1–11). 1 — palpomere 3; 2 — clypeus; 3 — lobes of antepronotum; 4 — tibial spurs of fore leg; 5–6 — hypopygium in dorsal and ventral view; 7 — tergite IX and anal point, lateral; 8–9 — inferior volsella, other aspects; 10–11 — gonostylus at obtuse and right angle. Here and in all other figures arrows indicate some distinguishing characters.

Рис. 1–11. Имаго самец *Bryophaenocladius bedumonti* Moubayed, sp.n. (1–11). 1 — 3-й членик максиллярного щупика; 2 — клипеус; 3 — доли переднеспинки; 4 — шпоры голени передней ноги; 5–6 — гипопигий, сверху и снизу; 7 — тергит IX и анальный отросток, сбоку; 8–9 — нижний придаток гонококсита в разных положениях; 10–11 — гоностиль под тупым и прямым углом. Здесь и на всех остальных рисунках стрелки указывают на некоторые отличительные признаки.

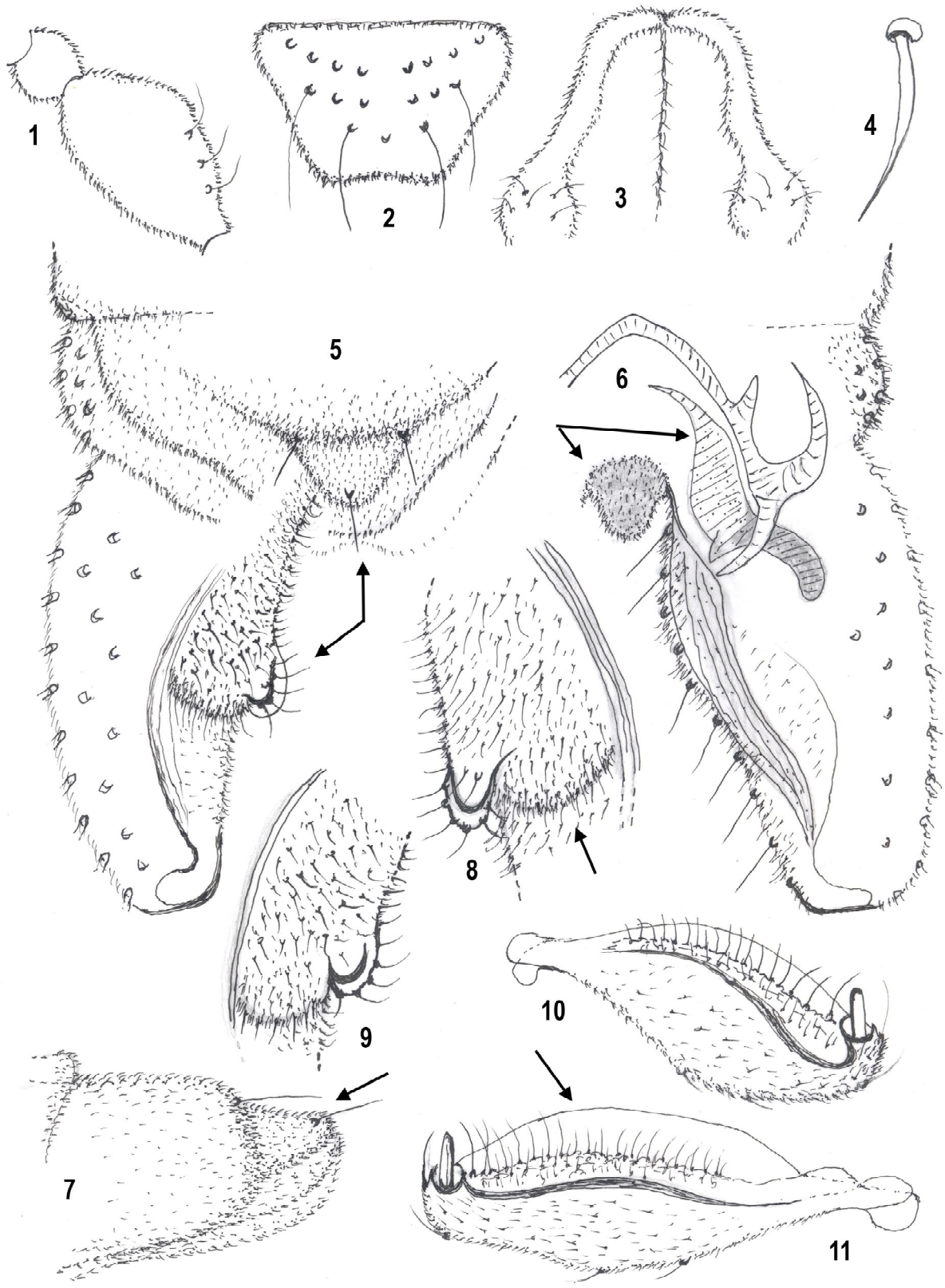
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Table 1. Lengths (in μm) and proportions of leg segments of *Bryophaenocladius bedumonti* Moubayed, sp.n., male (n = 1)

Таблица 1. Длина (в мкм) и пропорции члеников ног самца *Bryophaenocladius bedumonti* Moubayed, sp.n. (n = 1)

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
PI	510	680	425	255	185	120	95	0,63	2,47	2,80	2,0
PII	585	605	290	145	115	85	75	0,48	3,52	4,10	1,40
PIII	625	740	420	210	170	95	85	0,57	3,19	3,25	1,70

coxite (Figs 5–6) 200 μm long, 95 μm maximum width, with truncate apex, distal tubercle slight apical sclerotization; dorsal side with both proximal and median parts of setiferous inner area covered with setae; ventral side with a typical specific pars-ventralis (atypical character in the genus *Bryophaenocladius*) located at basal junction, large sclerotization present close to the inner margin. Inferior volsella (Figs 5, 8–9), 70–75 μm maximum length, 30–35 μm maximum width, consist of 2 parts: apical one large nose-like lobe, with bare apical margin and bearing a short rounded sclerotization covered with 5–6 setae; caudal part marsupial pouch-like covered with short and long setae; only the proximal and median parts of setiferous inner area covered with setae. Gonostylus (Figs10–11) about 100 μm long and 30 μm maximum width, slender, linearly elongate, without posterior projection, anterior area with sclerotization and covered with short and long setae, caudal part inwardly turned over; crista dorsalis large low lobe-like widely expanded, occupying the entire anterior side, clearly visible at right angle position; megaseta well-developed. HR = 2.0. HV = 1.7.

Male pupal exuvia. As in many *Bryophaenocladius* pupal exuviae, that of *B. bedumonti* Moubayed, sp.n. is entirely pale to transparent except for the antepronotal area which is often darker; frontal apotome moderately wrinkled, anteromedian and posterior areas smooth; abdomen, anal segment and genital sacs little darker than remaining parts of the exuvia.

Total length 2.50 mm. *Cephalothorax*. Frontal apotome (Fig. 12) not domed, frontal tubercles and frontal setae absent. Antepronotals, precorneals and dorsocentrals as if Figs 13–15. Thoracic horn absent; antepronotals 2 (45 and 30 μm long), precorneals 3 (30, 15 and 15 μm long); dorsocentrals subequal, about 5 μm long. *Abdomen* (Figs 16–17). Chaetotaxy and distribution pattern of shagreen, spinules and points of abdominal segments as figured in Pankratova [1970, Figs 147: 6–7], Coffman et al. [1986, Fig. 9.7] and Langton [1991, Fig. 69a]. Tergite I (Fig. 17) with 2 anteromedian groups of points; dense field of points present on tergites II–VIII. Anal lobe (Fig. 16) about 250 μm long and 300 μm maximum wide, well-expanded distally, with rounded apical margins; macrosetae absent; genital sac about 175 μm long, sub-rectangular and not reaching posterior margin of anal lobe.

Larva unknown.

Bryophaenocladius helveticus Moubayed et Lods-Crozet, **sp.n.**

Figs 18–30.

http://zoobank.org/NomenclaturalActs/12DD5FA0-F31D-420D-835B-1A0E66DE83CD.

Material. **Switzerland:** Holotype, ♂ adult, Muttbach glacial stream, Rhone catchment, h-1800–2090 m a.s.l., 46°43'39.678" N, 10°07'55.764" E, 03.VIII.1997, leg. B. Lods-Crozet (MZL, GBIFCH00611485). Environmental data of Mutt stream water are: crystalline to calcareous water, conductivity 61–183 μS/cm; temperature: 1–8 °C during late spring to late summer (June–September). Paratypes: 4♂ adults, same locality and date as for holotype, leg. B. Lods-Crozet (MZL, MCF).

Diagnostic characters. Based on the atypical shape of the inferior volsella, *B. helveticus* Moubayed et Lods-Crozet, sp.n. appears to belong to a separate group within the genus *Bryophaenocladius*. However, this new species is distinguished from other related European congeners (namely from *B. thaleri* Willassen, 1996) by the following characters. *Head*. Temporals 11; AR 0.95. *Thorax*. Lobes of antepronotum slightly gaping, thinner at base; acrostichals consist of 9 long setae in 1 row, beginning close to anterior margin of scutum; dorsocentrals 12; prealars 5 uniserial; scutellum with 8 setae. Wing not reduced, squama consists of 4 short setae. *Legs*. Sensilla chaetica present on tibia and tarsomeres of PI–PIII. *Abdomen*. Tergite IX with tergite bands occupying the lateral margins and base of anal point. Virga 2 small horseshoe-like, composed of 4 arched spines. Anal point broad drop-like shaped, with 11–12 setae located on basal and median areas, proximal half covered with microtrichia, distal part bare. Sternapodeme rounded orally; phallpodeme typically-shaped, with basal expansion long and spatulate, aedeagal lobe moderately swollen. Gonocoxite with truncate apex; dorsal side bearing sclerotization apically, distal sclerotized tubercle present; inferior volsella large lobe-like, with stout setae; only distal part of setiferous inner area swollen and covered with setae. Gonostylus projecting posteriorly, posterior side with a bare area distally; crista dorsalis low, often restricted to distal half of gonostylus.

Bryophaenocladius helveticus Moubayed et Lods-Crozet, sp.n. *male adult* can be differentiate from the congeners by the characters as follows: Based on the atypical shape of the inferior volsella and chaetotaxy of the setiferous inner area of gonocoxite, this new species appears to belong to a separate group within the genus *Bryophaenocladius*. Though *B. helveticus* Moubayed et Lods-Crozet, sp.n. shows a close morphological similarity with the brachypterous *B. thaleri* Willassen, 1996, which is only known from the Italian Alps (Pala Cima Vezzana, h ~ 3190 m a.s.l.; Pala Cima Bureloni, h ~ 3130 m a.s.l.), the following distinguishing characters will easily separate *B. helveticus* Moubayed et Lods-Crozet, sp.n. from *B. thaleri* and other related species in having wing not reduced, squama with 14–15 setae; anal tergite bands present on lateral margins of tergite IX and base of anal point; anal point broad drop-like; inferior volsella sub-rectangular; only distal part of setiferous area is covered with setae; phallapodeme typically shaped, with a characteristic spatulate basal expansion and a weakly swollen aedeagal lobe; crista dorsalis low and widely extended.

Etymology. The new species is named *helveticus* after the name of 'Swiss confederation' given in Italian of the country of Switzerland, where the type material was collected.

Description. *Male adult*. Large. Total length 3.55 mm. Wing length 1.85 mm; TL/WL 1.92. General colouration is ranging from brown to blackish; head blackish, antenna brown; thorax brown with blackish mesonotal stripes; legs uniformly brown; abdomen brownish, anal segment contrasting from dark brown to blackish.

Head. Temporals 11 (8 inner and 3 outer verticals); antenna 875 µm, last flagellomere 425 µm long, antennal groove reaching segment 3, AR 0.95; clypeus (Fig. 18) 85 µm long, 95 µm maximum wide, sub-rectangular, with 7–8 setae; palp (Fig. 19) 5-segmented, palpomere 3 without apical projection, with 3 sensilla clavata, sensilla coeloconica absent. Thorax. Lobes of antepronotum (Fig. 20) slightly gaping antepronotals 5, thinner at base, swollen in its proximal half; acrostichals long (about 8–9 µm long), consist of 9 setae in 1 row; dorsocentrals 12 in 1–2 rows; prealars 5 uniserial; scutellum with 8 uniserial setae (4 on each side of the midline). Wing. Brachiolum with 1 seta; subcosta reaching the fork of radius. Distribution of setae on veins: R, 11; R_1, 4; remaining veins bare; squama with 4–6 setae (Occasionally 2). Legs. Tibial spurs on: PI (1, 60 µm long), PII (2, 50, 25), PIII (2, 65, 25); pseudospurs present on tibia and tarsomeres ta_1–ta_3 of PII–PIII. Sensilla chaetica present on: tibia and tarsomeres ta_1–ta_5 of PI; tibia and tarsomeres ta_1–ta_4 of PII–PIII. Length (in µm) and proportions of prothoracic (PI), mesothoracic (PII) and metathoracic (PIII) legs as in Table 2.

Abdomen. Hypopygium in dorsal and ventral view as in Figs 21–22; ventral view (Fig. 22) with tergite IX and anal point removed. Tergite IX broadly sub-rectangular at base, narrowing distally, anal lateral tergite band well-developed, occupying the lateral margins and base of anal point; dorsal hump weakly projecting as illustrated in lateral view (Figs 24–25). Anal point 60–65 µm long, 120–130 µm maximum width, with 11–12 setae located on lateral and median parts; in dorsal view (Fig. 21) large drop-like shaped, in lateral view (Figs 24–25) beak-like shaped, proximal and median areas covered with microtrichia, basal margin with linear sclerotization. Virga composed of 4 arched spines arranged in 2 small horseshoe-like figure. Transverse sternapodeme broadly rounded and not projecting orally. Phallapodeme well-developed, basal expansion long and spatulate, aedeagal lobe moderately swollen medially. Gonocoxite (Figs 21–22) 240 µm long, 120 µm maximum width, truncate apically, distal tubercle present; dorsal side as in figure 21; only distal part of the setiferous inner area is covered with setae (about 25–33), proximal and median parts bare; ventral side with a fine longitudinal sclerotization located close to the inner margin. Inferior volsella (Figs 21, 30) rectangular to large lobe-like, 30–35 µm as long as wide, with 7–13 setae placed in 2–3 rows on apical margin and along a short rounded sclerotization. Gonostylus (Figs 26–29) about 115 µm long and 45 µm maximum width, posteriorly projecting; anterior side covered with short and long setae; posterior side bearing a characteristic bare area distally; crista dorsalis low lobe-like widely expanded along the distal half of gonostylus (occasionally occupying the entire anterior side); megaseta well-developed. HR = 2.09. HV = 3.09.

Female adult, pupal exuvia and *larva* unknown.

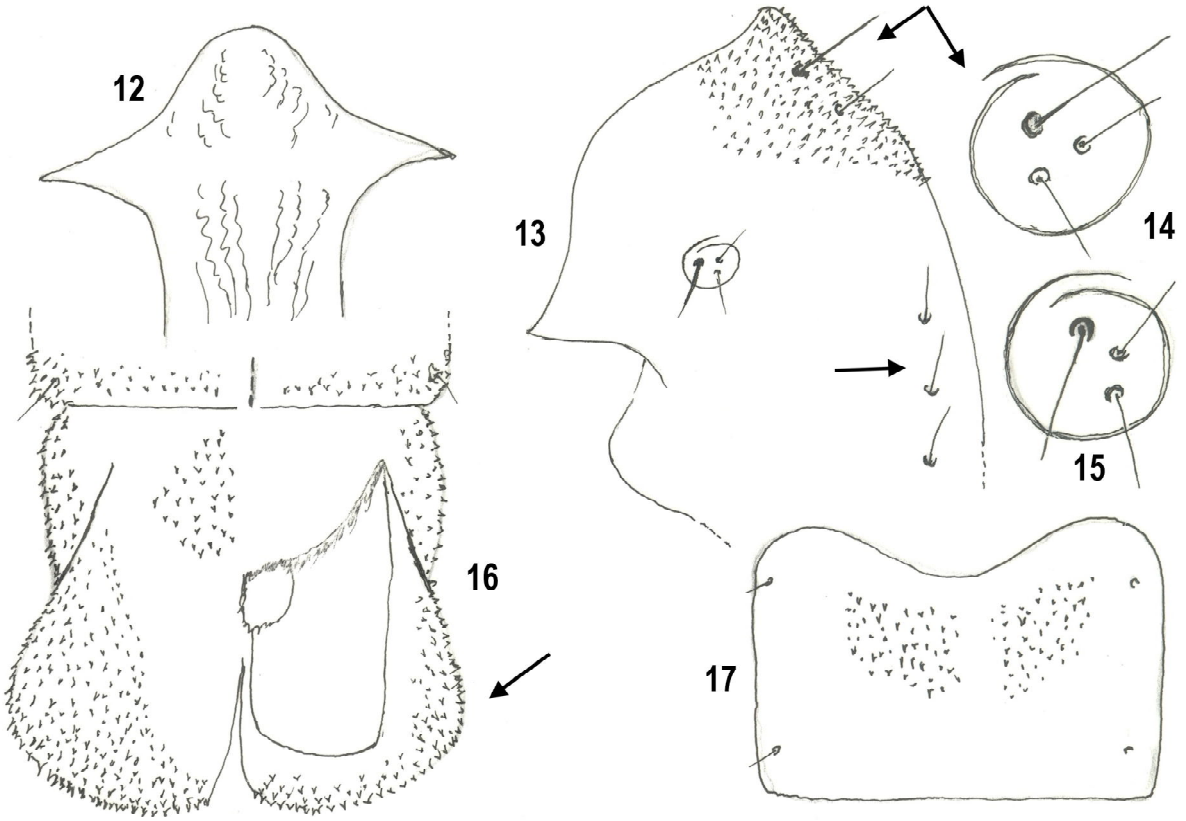
Bryophaenocladius tyrrhenius Moubayed, **sp.n.**

Figs 33–39.

http://zoobank.org/NomenclaturalActs/393F700E-74B0-4E70-A6C2-E6EB017D71FA.

= *Bryophaenocladius* sp. 2: Moubayed-Breil, 2020;

= *Bryophaenocladius* sp. 3: Moubayed-Breil, Ashe, 2016.



Figs 12–17. Male pupal exuvia of *Bryophaenocladius bedumonti* Moubayed, sp.n. (12–17). 12 — frontal; 13 — thorax; 14–15 — precorneal setae; 16 — segment VIII and anal lobe, dorsal and ventral; 17 — tergite I, dorsal.

Рис. 12–17. Экзувий куколки самца *Bryophaenocladius bedumonti* Moubayed, sp.n. (12–17). 12 — фронтальная область; 13 — грудь; 14–15 — прекорнеальные щетинки; 16 — сегмент VIII и анальная лопасть, сверху и снизу; 17 — тергит I, сверху.

Table 2. Lengths (in μm) and proportions of leg segments of *Bryophaenocladius helveticus* Moubayed et Lods-Crozet, sp.n., male (n = 1)

Таблица 2. Длина (в мкм) и пропорции члеников ног самца *Bryophaenocladius helveticus* Moubayed et Lods-Crozet, sp.n. (n = 1)

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
PI	780	890	570	325	240	155	110	0.64	2.70	2.93	2.0
PII	795	810	375	235	185	120	105	0.46	3.07	4.28	3.20
PIII	885	955	595	330	255	155	110	0.62	2.86	3.09	2.75

Material. **Continental France:** Holotype, ♂ adult, Soques glacial springs and stream, Mantet Nature Reserve, Eastern-Pyrenees; h ~ 2000–2200 m a.s.l.; 42°28'38" N, 02°18'26" E; 8.VIII.2008, leg. J. Moubayed (MZL). Environmental data of water are: crystalline water, conductivity (Cd) 20–25 μS/cm; temperature (T °C), 6.5–8.0 during late spring, 9–12 during late summer; pH acid, 5.1–5.5; Paratypes: 2♂ adults, same locality and same environmental data as for holotype, leg. J. Moubayed (MCF); 2♂ adults, Massane Nature Reserve, Eastern-Pyrenees, h ~ 850 m a.s.l., 42°28'41" N, 3°01'6" E, 6.VI.2013, leg. J. Moubayed (MCF).

Etymology. The species name *tyrrhenius* refers to the Tyrrhenian Province, which geographically covers Corsica, Sardinia, Sicily and the Tyrrhenian area of Continental France, Italy and Spain.

Diagnostic characters. *Male adult. Head*. Frontal tubercles absent, temporals 14; AR 1.85. *Thorax* densely covered with setae. Lobes of antepronotum not gaping; acrostichals 23, decumbent; dorsocentrals 41; prealars 14, scutellum with 36 thick and thin setae in 2 rows. *Wing*. Squama with 16–21 setae. *Abdomen*. Tergite IX sub-rectangular, posterior margin nearly straight, with distinct lateral anal tergite band. Anal point broadly triangular with 12–14 setae, in 2 rows; lateral expansions well-developed, basal margin with sclerotization, microtrichia present on proximal half. Virga faintly figured, consists of 2 divergent spines. Sternapodeme markedly projects orally. Phallpodeme typically shaped, basal expansion thin with pointed apex; aedeagal lobe strongly swollen. Gonocoxite truncate apically; basal junction without 'pars-ventralis', dorsal tubercle indistinct on distal part; inferior volsella nose-like shaped, strongly curved downwards, apical part with distinct sclerotization, setae present only on apical margin; proximal and distal parts of setiferous inner area covered with setae, median part bare. Gonostylus linearly elongate, posterior tip inwardly projecting; crista dorsalis large low lobe-like, widely expanded. See also comparative diagnosis given under *B. vernensis* Moubayed, sp.n.

Description. *Male adult.* Small species. Total length 2.65 mm. Wing length 1.87 mm. General colouration contrasting pale brown to dark brown. Head dark brown to blackish, antenna brownish; thorax contrasting brown to dark brown with blackish mesonotal stripes; legs uniformly brownish; abdomen brownish, anal segment contrasting from dark brown to blackish.

Head. Eyes bare. Frontal tubercles absent; temporals 11 including 8 inner and 3 outer verticals. Antenna 13-segmented, 1.870 μm long, last flagellomere 630 μm long, AR 1.85; antennal groove beginning on segment 2. Clypeus (Fig. 31) 100 μm long, 110 μm maximum width, sub-trapezoidal to sub-rectangular, with 17 setae in 3 rows Palp 5-segmented, palpomere 3 (Fig. 32) 115–125 μm long, with 3 sensilla clavata, posterior expansion absent. *Thorax*. Antepronotum well-developed, antepronotal lobes not gaping, lateral antepronotals 6; acrostichals consist of 23 decumbent setae in 2 rows, starting close to scutum margin; dorsocentrals 36–41 in 1–3 rows; prealars 14 in 1–2 rows; supraalars absent; scutellars 32–36 uniserial, including 8–10 thinner setae. Humeral pit sub-oval. *Wing*. Brachiolum with 2 setae; subcosta reaching fork of radius, costal expansion 25 μm long. Distribution of setae on veins: R, 15–17; R_1, 7–9; remaining veins bare; squama with 17–19 setae. *Legs*. Tibial spurs of: PI 75 μm long, PII–PIII 60, 30 and 65, 35; pseudospurs present on ta_1–ta_3 of PII–PIII. Sensilla chaetica present on: tibia and tarsomeres ta_1–ta_5 of PI; tibia and tarsomeres ta_1–ta_4 of PII–PIII. Length (in μm) and proportions of prothoracic (PI), mesothoracic (PII) and metathoracic (PIII) legs as in Table 3. *Abdomen*. Hypopygium in dorsal and ventral view as in Figs 33–34; ventral view (Fig. 34) with tergite IX and anal point removed. Tergite IX broadly sub-rectangular, posterior margin nearly straight, with distinct anal tergite band on lateral margins and base of anal point. Anal point (Fig. 33, dorsal; Fig. 36, lateral) about 65 μm long and 110 μm maximum width, broad triangle-like, bearing 12–14 setae located close to the basal tergite band; lateral expansions well-developed, about 25 μm long, clearly visible in both dorsal and lateral view, almost reaching lateral margin of tergite IX; median area densely covered with microtrichia. Virga (Figs 33, 35) indistinct but present, consists of 2 divergent spines. Transverse sternapodeme (Fig. 34) well projecting orally and pointed at base, lateral expansion rounded. Phallpodeme characteristic, basal expansion thin with pointed apex; aedeagal lobe broadly swollen. Gonocoxite (Fig. 33) 250 μm long, 120 μm maximum width, truncate apically, distal tubercle weakly-developed; dorsal side with both proximal and distal parts of setiferous inner area covered with setae median par bare; large sclerotization present close to the inner margin. Inferior volsella (Figs 33, 37), about 30–35 μm long, nose-like shaped, strongly turned over and curved downwards, apical part with distinct sclerotization close to the inner margin, setae present only on apical margin; only proximal and distal parts of setiferous inner area covered with setae, median part typically bare. Gonostylus (Figs 38–39) about 100 μm long and 30 μm maximum width, slender and linearly elongate; anterior area with sclerotization and covered with short and long setae; posterior tip slightly projecting and inwardly turned over; crista dorsalis large low lobe-like, occupying the entire anterior side; megaseta well-developed. HR = 2.0. HV = 2.65.

Figs 18–27. Male adult of *Bryophaenocladius helveticus* Moubayed et Lods-Crozet, sp.n. (18–27). 18 — clypeus; 19 — palpomere 3; 20 — lobes of antepronotum; 21–22 — hypopygium in dorsal and ventral view; 23 — virga; 24–25 — tergite IX and anal point in lateral view; 26–27 — gonostylus at acute and right angle.

Рис. 18–27. Имаго самец *Bryophaenocladius helveticus* Moubayed et Lods-Crozet, sp.n. (18–27). 18 — клипеус; 19 — 3-й членик максиллярного щупика; 20 — доли переднеспинки; 21–22 — гипопигий, сверху и снизу; 23 — вирга; 24–25 — тергит IX и анальный отросток, сбоку; 26–27 — гоностиль под острым и прямым углом.

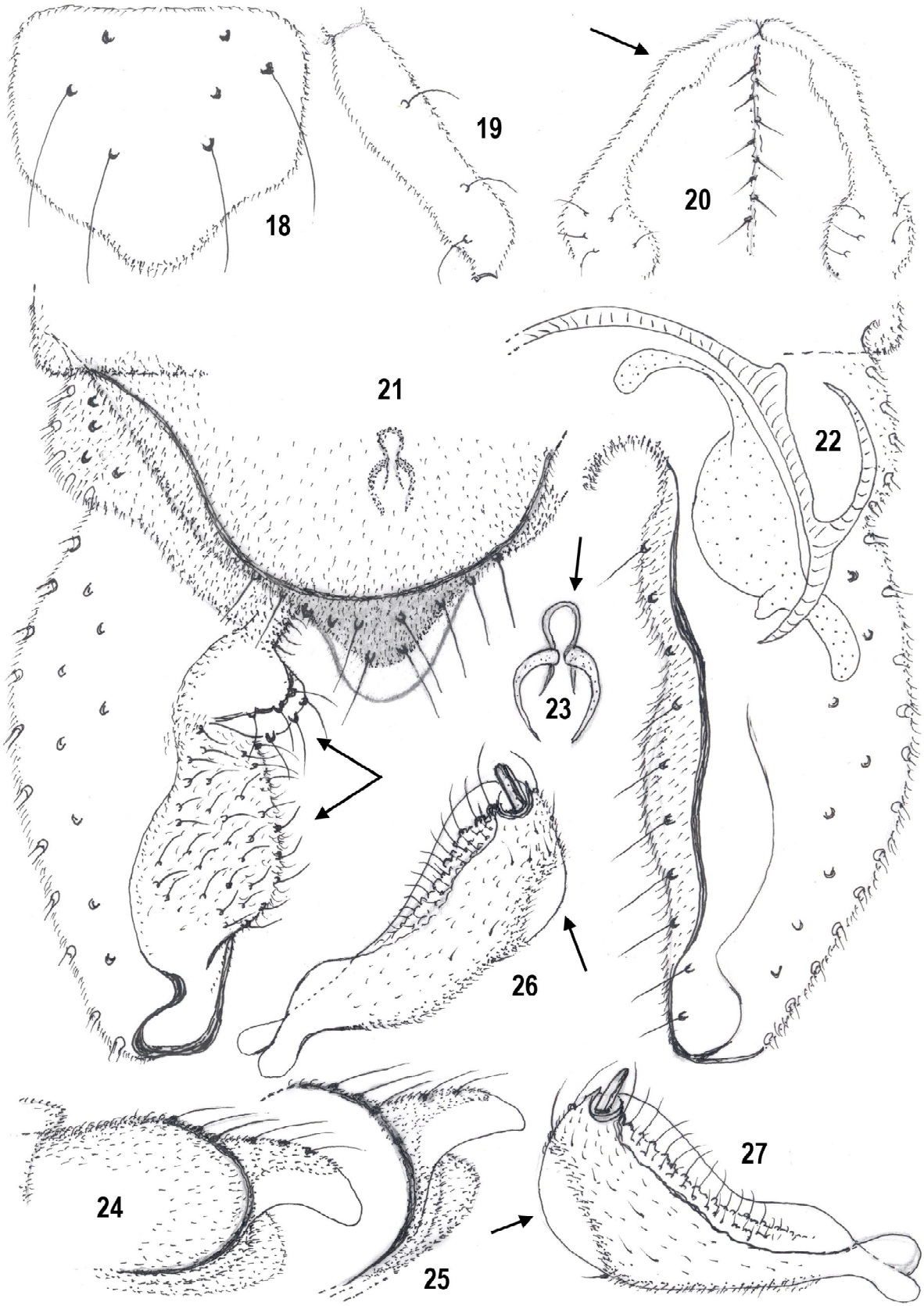

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Table 3. Lengths (in μm) and proportions of leg segments of *Bryophaenocladius tyrrhenius* Moubayed, sp.n., male (n = 1)
Таблица 3. Длина (в мкм) и пропорции члеников ног самца *Bryophaenocladius tyrrhenius* Moubayed, sp.n. (n = 1)

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
PI	780	875	540	315	235	145	110	0.62	2.73	3.06	2.50
PII	930	850	310	230	165	115	95	0.36	3.45	5.74	2.0
PIII	775	925	585	275	215	120	100	0.63	3.22	2.91	2.25

Female adult, pupal exuvia and *larva* unknown.

Bryophaenocladius vernensis Moubayed, **sp.n.**

Figs 40–50.

http://zoobank.org/NomenclaturalActs/40BB8583-61E2-4988-805D-A8FB816CD485.

Material. **Continental France:** Holotype, ♂ pharate adult, karstic spring, upper basin of Verne stream, Var Department (SE-France), h ~ 400 m a.s.l.; 43°26'0" N, 6°47'0" E, 24.V.2005, leg. J. Moubayed (MZL). Environmental data of spring: calcareous water, conductivity about 430 μS/cm; temperature 8–12 °C. Paratypes: 1♂ adult, same locality and data as for holotype; 1♂ adult, Valescure karstic springs and ruisselet, upper basin of the Real Collobrier River, h ~ 350 m a.s.l., Var Department, (SE-France); 43°26'0" N, 6°47'0" E, 24.V.2005, leg. J. Moubayed (MCF).

Ethymology. The name *vernensis* of the new species refers to the type locality of the Verne stream (south eastern France) where the type material was collected.

Diagnostic characters. Male adult of *B. vernensis* Moubayed, sp.n. can be separated from all members of the genus *Bryophaenocladius* by a combination of distinguishing characters. Head with well-developed frontal tubercles. Thorax with 23 decumbent acrostichals, 41 dorsocentrals and 14 prealars. Squama with about 19 setae. Hypoygium with lateral anal tergite band extended only on lateral sides; anal point drop-like, with short lateral expansions, dorsal setae (11–12) mostly located on lateral margins, basal and apical parts lacking margins; virga present, bell-like shaped; aedeagal lobe strongly swollen; inferior volsella digitiform and projecting, with 6 apical setae; setiferous inner area of gonocoxite bearing setae on median and distal parts, proximal part bare; gonostylus linearly elongate, posterior angle bare; crista dorsalis large lobe-like, orally projecting and widely expanded.

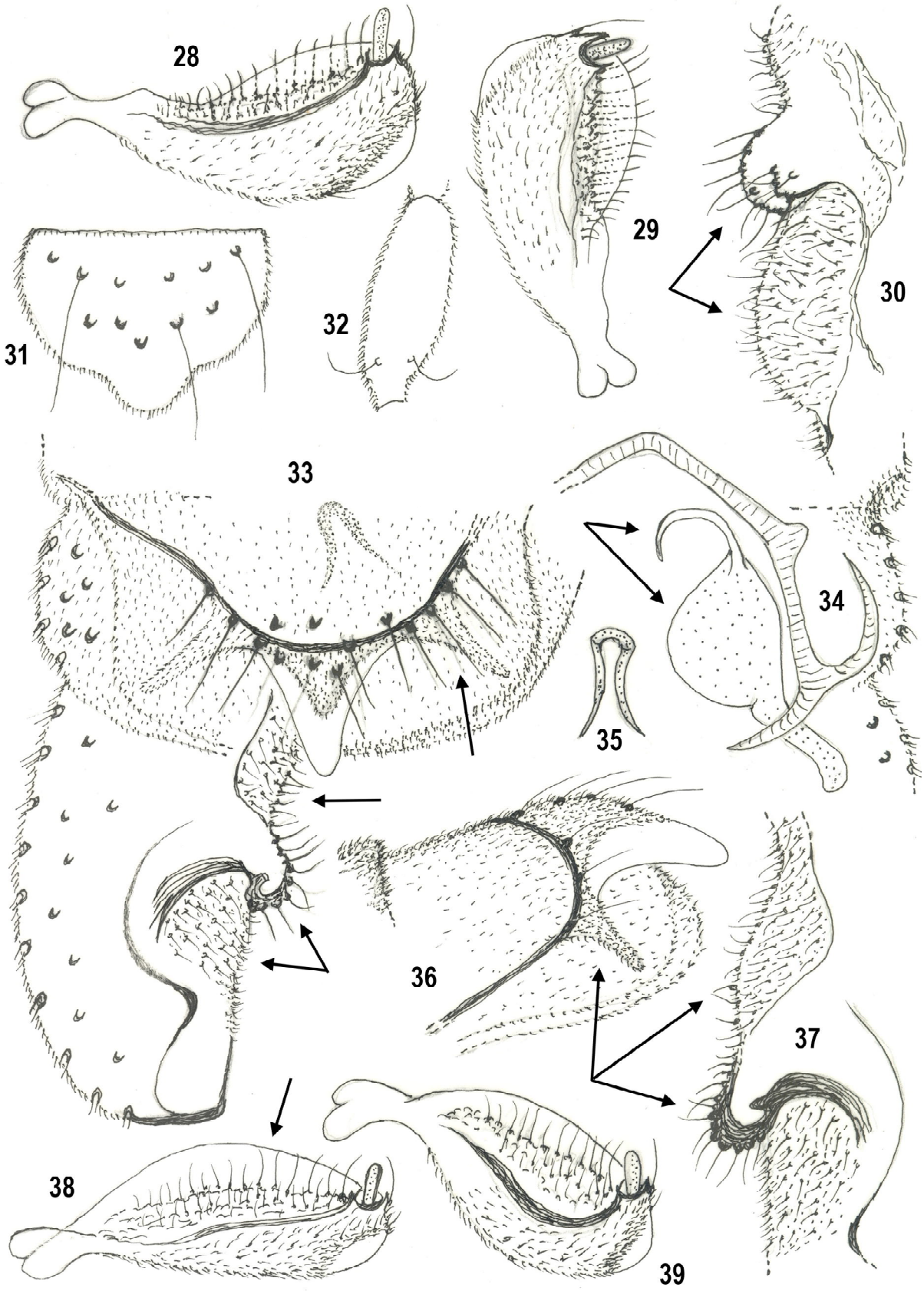
Bryophaenocladius tyrrhenius Moubayed, sp.n. and *B. vernensis* Moubayed, sp.n. can be compared with the congeners by the following characters: the male adult can be separated from morphologically similar congeners *B. nidorum*, *B. scanicus* and *B. tuberculatus* by tergite anal bands, anal point, inferior volsella and setiferous inner area of gonocoxite, which are different from what is observed in *B. nidorum*, *B. scanicus* and *B. tuberculatus*. In particular, the shape of anal point in both dorsal and lateral view (Figs 33, 36, 43 and 45) and that of the aedeagal lobe (Figs 34, 46 and 58) are differently figured in the 3 latter 3 species as illustrated in Figs 51,53, 56–57 and 59.

Description. *Male adult.* Small species. Total length 2.30 mm. Wing length 1.35 mm. TL/WL 1.70. General colouration contrasting pale brown to dark brown. Head, thorax and apodemes dark brown to blackish; abdomen including anal segment contrasting pale brown to dark brown.

Head (Fig. 40). Eyes bare. Frontal tubercles well-developed; temporals 10 including 7 inner and 3 outer verticals. Antenna 13-segmented, 850 μm long, last flagellomere 550 μm long, AR 1.83; antennal groove beginning on segment 3. Clypeus (Fig. 41) 65 μm long, 95 μm maximum width, sub-trapezoidal, rounded apically, with 11 setae in 3 rows. Palp 5-segmented, posterior expansion absent. *Thorax*. Lobes of antepronotum (Fig. 42) not gaping, lateral antepronotals 6; acrostichals consist of 16 long setae (15 m long), beginning close to scutum margin; dorsocentrals 13 in 1–2 rows; prealars 5 in 1 row; scutellars 18 in 3 rows; humeral pit absent. *Wing*. Brachiolum with 2 setae; subcosta reaching fork of radius, costal expansion 15–20 μm long. Distribution of setae on veins: R, 15; R_1, 10–11; remaining veins bare; squama with 14–15 setae in 1–2 rows. *Legs*. Tibial spurs of: PI 70 μm long, PII–PIII 40, 20 and 45, 25; pseudospurs present on ta_1–ta_3 of PII–PIII. Sensilla chaetica present on: tibia and tarsomeres ta_1–ta_5 of PI; tibia and tarsomeres ta_1–ta_4 of PII–PIII. Length (in μm) and proportions of prothoracic (PI), mesothoracic (PII) and metathoracic (PIII) legs as in Table 4. *Abdomen*. Hypopygium in dorsal and ventral view as in Figs 45–46; ventral view (Fig. 46) with tergite IX and anal point removed. Tergite IX broadly sub-rectangular at base and median parts, narrowing posteriorly; distinct anal tergite band present on lateral margins, are typically interrupted at base of anal point. Anal point (Fig. 43, lateral; Fig. 45, dorsal) about 70 μm long and 75 μm maximum width, broad drop-like shaped; dorsal setae (10–12) mostly located along the lateral margins (1 is occasionally placed on median part); lateral expansions short (about 10–15 μm long), clearly visible in both lateral and dorsal view as in figures 43, 45, almost reaching lateral margin of tergite IX; entire dorsal surface densely covered with microtrichia. Virga (Figs 44–45, 47) present, bell-like shaped, consisting of 2 large arched spines. Transverse sternapodeme (Fig. 46) well projecting orally, slightly pointed at base, lateral expansion rounded; lateral sternapodeme 40 μm long. Phallpodeme typically shaped, basal expansion thin and pointed apically; aedeagal lobe markedly swollen. Gonocoxite (Figs 45–46) 210 μm long, 175 μm maximum width, with rounded apex, distal tubercle well-developed; dorsal side with both median and posterior parts of setiferous inner area covered with setae, proximal part bare; ventral side with linear sclerotization extending from basal to caudal part of gonocoxite along the inner margin. Inferior volsella (Figs 45, 48), about 40 μm long, 45 μm

Figs 28–39. Male adult of *Bryophaenocladius helveticus* Moubayed et Lods-Crozet, sp. n. (28–30) and *B. tyrrhenius* Moubayed, sp. n. (31–39). 28 — gonostylus at right angle; 29 — gonostylus, lateral; 30, 37 — inferior volsella and setiferous inner area of gonocoxite; 31 — clypeus; 32 — palpomere 3; 33–34 — hypopygium in dorsal and ventral view; 35 — virga; 36 — tergite IX and anal point in lateral view; 38–39 — gonostylus at right and obtuse angle.

Рис. 28–39. Имаго самец *Bryophaenocladius helveticus* Moubayed et Lods-Crozet, sp.n. (28–30) и *B. tyrrhenius* Moubayed, sp.n. (31–39). 28 — гоностиль под прямым углом; 29 — гоностиль, сбоку; 30, 37 — нижний придаток и щетинконосная внутренняя область гонококсита; 31 — клипеус; 32 — 3-й членик максиллярного щупика; 33–34 — гипопигий, сверху и снизу; 35 — вирга; 36 — тергит IX и анальный отросток, сбоку; 38–39 — гоностиль под прямым и острым углом.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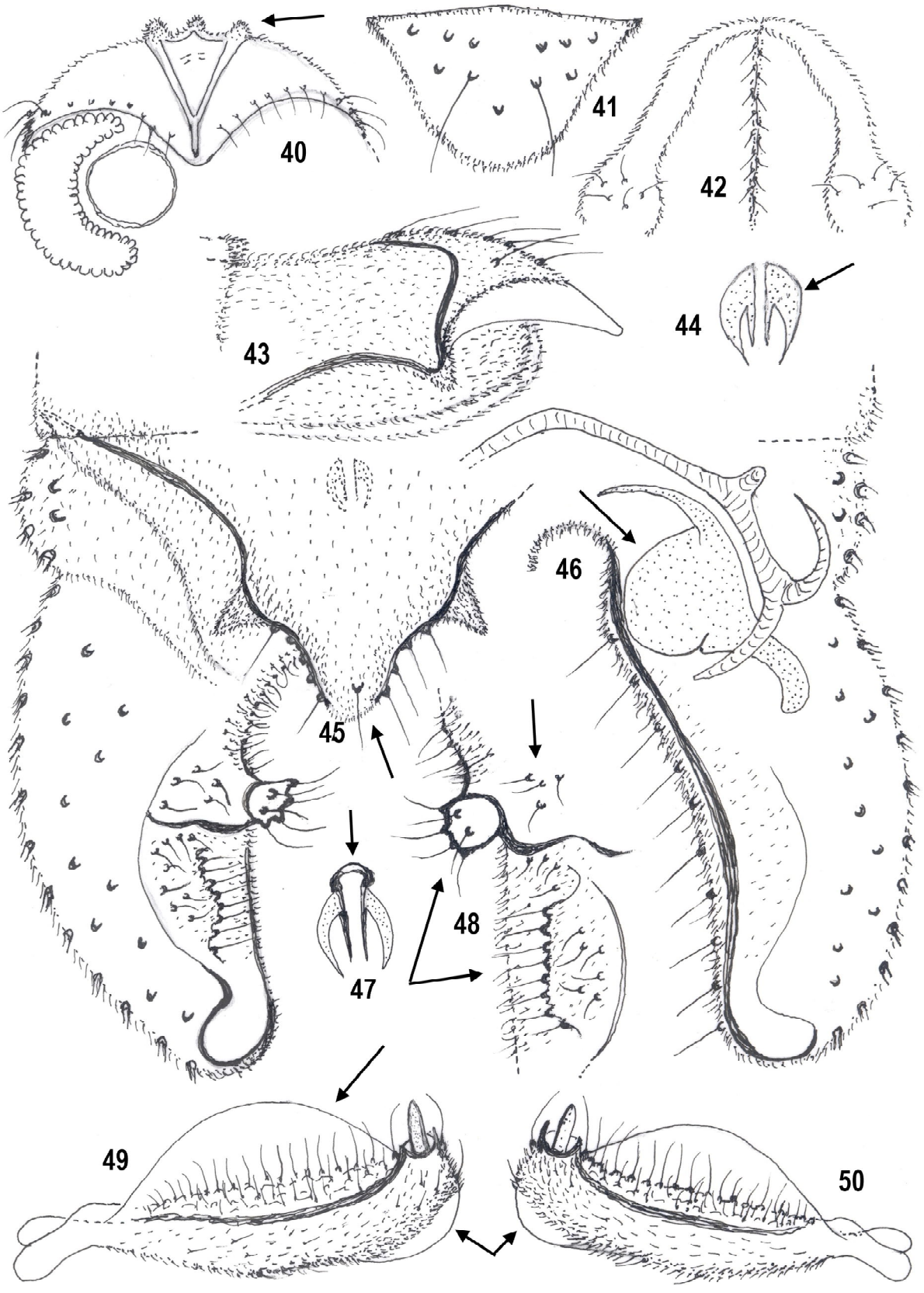
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Table 4. Lengths (in μm) and proportions of leg segments of *Bryophaenocladius vernensis* Moubayed, sp.n., male (n=1)
Таблица 4. Длина (в мкм) и пропорции члеников ног самца *Bryophaenocladius vernensis* Moubayed, sp.n. (n=1)

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
PI	650	635	340	210	160	115	85	0.54	2.85	3.78	2.25
PII	570	590	310	165	135	95	80	0.53	3.09	3.74	1.60
PIII	615	675	430	225	185	105	95	0.64	2.82	3.00	1.80

maximum width, digitiform, strongly projecting at right angle, apical part with distinct arched sclerotization, setae present on apical part and inner margin; only median and distal parts of setiferous inner area covered with setae, proximal part bare, median part with 4–5 setae, distal part composed of 17–18 setae including 9 arranged along a typical vertical row. Gonostylus (Figs 49–50) 110 μm long and 45 μm maximum width, linearly elongate, not projecting posteriorly; anterior area with transverse sclerotization and covered with short and long setae; posterior tip bearing a bare posterior angle; crista dorsalis well-developed, large lobe-like, occupying the entire anterior side; megaseta well-developed. HR = 1.91. HV = 2.09.

Female adult, pupal exuvia and *larva* unknown.

Taxonomic remarks

Based on some morphological distinguishing characters found in the male adult, the four new species can be separated from morphologically similar congeners by a combination of characters, which are highlighted in the following differential diagnosis.

B. helveticus Moubayed et Lods-Crozet, sp.n. belongs to a local Alpine element, while *B. tyrrhenius* Moubayed, sp.n. to a local Tyrrhenio-pyrenean element. Currently, about 80 known *Bryophaenocladius* species are reported from the Palaearctic Region, of which 33 are known from Europe. Consequently the description of *B. bedumonti* Moubayed, sp.n., *B. helveticus* Moubayed et Lods-Crozet, sp.n., *B. tyrrhenius* Moubayed, sp.n. and *B. vernensis* Moubayed, sp.n. increases the total number in the genus to 37 valid species from Europe.

Although some relevant morphological characters are detailed in the present paper, it is not feasible to provide a key to known male adult of the genus *Bryophaenocladius* from Europe until sufficient material of all species has been examined and compared.

Ecology and geographical distribution. Material of the four new described *Bryophaenocladius* species was collected in aquatic and semiterrestrial habitats bordering cold springs and streams. Enriched substratum in humus, abundant emerged and submerged bryophytes, deciduous woods and bark trees, seam to represent the most favourable microhabitats for their larval populations. *B. bedumonti* Moubayed, sp.n. and *B. vernensis* Moubayed, sp.n. are known from lower cold springs and streams in southern France (h ~ 350–400 m a.s.l.). *B. helveticus* Moubayed et Lods-Crozet, sp.n. and *B. tyrrhenius* Moubayed, sp.n. are confined to glacial helocrenes and cold stenothermic streams located in the Swiss Alps (Muttbach Valley, Rhone catchment, altitude 1800 m) and both Eastern-Pyrenees and Corsica (h~ 1700–2000 m a.s.l.). Consequently, *B. bedumonti* Moubayed, sp.n., *B. helveticus* Moubayed et Lods-Crozet, sp.n., *B. tyrrhenius* Moubayed, sp.n. and *B. vernensis* Moubayed, sp.n. likely belongs to the crenophilous community of chironomid species as documented by Lindegaard [1995].

B. helveticus Moubayed et Lods-Crozet, sp.n. is only known from the lower basin of the Mutt glacial stream (Swiss Alps), therefore this species can be expected to occur in other similar high mountainous areas situated in Switzerland and neighbouring countries (Italy, France, Austria, Poland). Geographical distribution of the remaining 3 species is currently restricted to springs and streams delimited by the Mediterranean coastal ecosystem of continental France. *B. bedumonti* Moubayed, sp.n. and *B. vernensis* Moubayed, sp.n. are exclusively reported from southeastern lower areas (h ~ 350–450 m a.s.l.), while *B. tyrrhenius* Moubayed, sp.n. is confined to glacial springs and streams located in Eastern-Pyrenees (h ~ 2000–2200 m a.s.l.).

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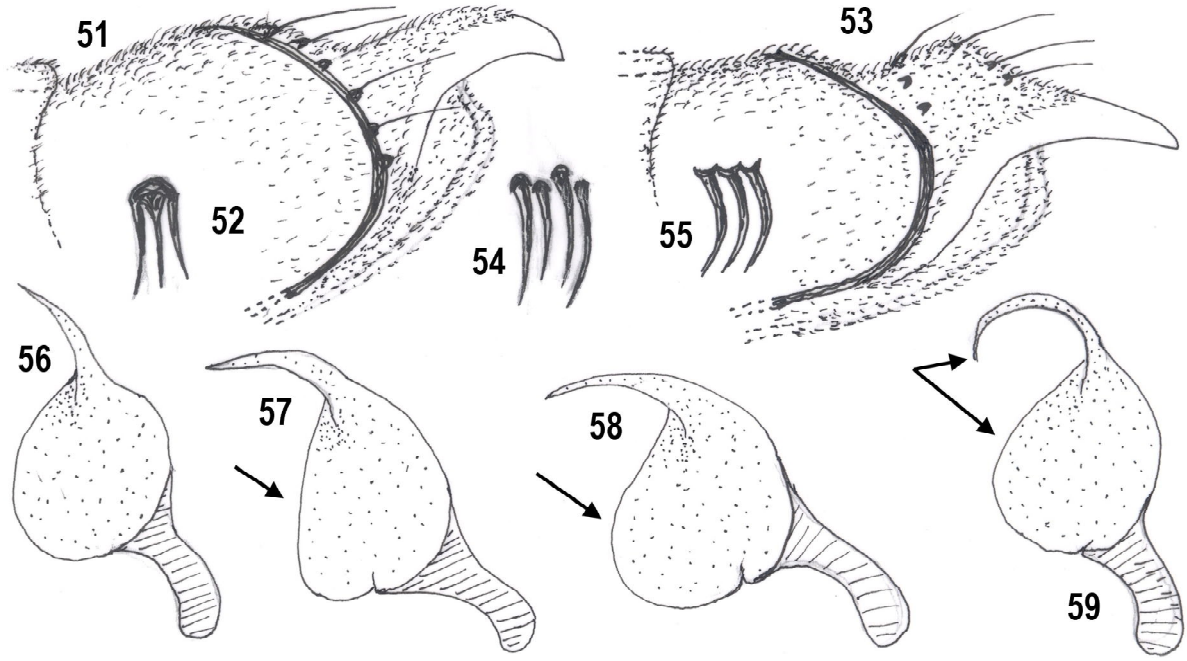
Figs 40–50. Male adult of *Bryophaenocladius vernensis* Moubayed, sp.n. (40–50). 40 — head; 41 — clypeus; 42 — lobes of antepronotum; 43 — tergite IX and anal point in lateral view; 44, 47 — virga; 45–46 — hypopygium in dorsal and ventral view; 48 — inferior volsella and setiferous inner area of gonocoxite; 49–50 — gonostylus at right and acute angle.

Рис. 40–50. Имаго самец *Bryophaenocladius vernensis* Moubayed, sp.n. (40–50). 40 — голова; 41 — клипеус; 42 — доли переднеспинки; 43 — тергит IX и анальный отросток, сбоку; 44, 47 — вирга; 45–46 — гипопигий, сверху и снизу; 48 — нижний придаток и щетинконесущая внутренняя область гонококсита; 49–50 — гоностиль под прямым и острым углом.



Figs 51–59. *Bryophaenocladius nidorum* (Edwards) (51–52, 56), *B. tuberculatus* (Edwards) (53–55, 59), *B. scanicus* (Brundin) (57) and *B. vernensis* Moubayed, sp.n. (58). 51, 53 — tergite IX and anal point in lateral view; 52, 54–55 — virga; 56–59 — aedeagal lobe of phallapodeme.

Рис. 51–59. *Bryophaenocladius nidorum* (Edwards) (51–52, 56), *B. tuberculatus* (Edwards) (53–55, 59), *B. scanicus* (Brundin) (57) и *B. vernensis* Moubayed, sp.n. (58). 51, 53 — тергит IX и анальный отросток, сбоку; 52, 54–55 — вирга; 56–59 — эдеагальная лопасть фаллаподемы.

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