

On the genus *Bryophaenocladus* Thienemann, 1934
(Diptera: Chironomidae, Orthoclaadiinae).

II. Description of three new species from continental France

О роде *Bryophaenocladus* Thienemann, 1934
(Diptera: Chironomidae, Orthoclaadiinae).

II. Описание трёх новых видов из континентальной Франции

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Ключевые слова: Diptera, Chironomidae, *Bryophaenocladus*, новый вид, континентальная Франция, охрана окружающей среды.

Abstract. *Bryophaenocladus poneli* Moubayed, Langton, **sp.n.**, *B. righetii* Moubayed, Langton, **sp.n.** and *B. vosgensis* Moubayed, Langton, **sp.n.** are diagnosed and described based on material recently collected in cold springs and streams located in continental France, Eastern Pyrenees, Cevennes and Vosges regions. *B. poneli* **sp.n.** is described as male adult and pupal exuviae, the two other species only as male adults. On the basis of some distinctive characters found in the male adult, *B. poneli* **sp.n.** and *B. vosgensis* **sp.n.** appear to belong to a local biogeographic element, while *B. righetii* **sp.n.** shows some morphological similarity with *B. femineus* Edwards, 1929. Currently, 18 *Bryophaenocladus* species are reported from continental France. Consequently, the description of the latter 3 new species increases the total number in the genus to 21 accepted valid species from this country. Discussion, differential diagnosis and comments on the ecology and geographical distribution of the new species are given.

Резюме. По материалу, недавно собранному в холодных источниках и ручьях континентальной части Франции в Восточных Пиренеях, районы Севенна и Вогеза, приводятся иллюстрированные описания хирономид *Bryophaenocladus poneli* Moubayed, Langton, **sp.n.**, *B. righetii* Moubayed, Langton, **sp.n.** и *B. vosgensis* Moubayed, Langton, **sp.n.** Описание для первого вида дано по имаго самцу и экзuvia куколки, а для остальных только по самцу. На основании некоторых отличительных признаков, обнаруженных у взрослых самцов, *B. poneli* **sp.n.** и *B. vosgensis* **sp.n.**, по-видимому, принадлежат к местному биogeографическому элементу, в то время как вид *B. righetii* **sp.n.** обнаруживает некоторое морфологическое сходство с *B. femineus* Edwards, 1929. До настоящего времени для континентальной Франции было отмечено 18 видов *Bryophaenocladus*. Описание трёх новых видов увеличивает общее количество видов в роде для этого региона до 21. Приводятся обсуждение, дифференциаль-

ные диагнозы и комментарии по экологии и географическому распространению новых видов.

Introduction

An extensive material recently collected in continental France reveals the presence of three new species, *B. poneli* **sp.n.**, *B. righetii* **sp.n.**, and *B. vosgensis* **sp.n.**, which are described and diagnosed. *B. poneli* **sp.n.** is described as male adult and pupal exuviae, while *B. righetii* **sp.n.** and *B. vosgensis* **sp.n.** only as male adults. Based on the recently supplemented generic diagnosis as documented in Moubayed and Lods-Crozet [2022] and various taxonomic and biogeographical data from the literature [Brundin, 1947, 1956; Strenzke, 1957; Sæther, 1973; Coffman et al., 1986; Cranston, Armitage, 1988; Armitage, 1987; Caspers, Reiss, 1987; Cranston et al., 1989; Willassen, 1996; Andersen, Schnell, 2000; Kaczorowska, Gilka, 2002; Wang et al., 2001, 2006; Makarchenko, Makarchenko, 2006, 2009, 2012; Langton, Pinder, 2007; Ding et al., 2011; Donato, 2011; Ashe, O'Connor, 2012; Sæther, Spies, 2013], *B. poneli* **sp.n.** and *B. vosgensis* **sp.n.** can be considered to be local biogeographic elements. Taxonomic remarks on related *Bryophaenocladus* species, with comments on the ecology and geographical distribution of the new species are given.

Material and methods

The examined material was 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. Specimens were checked under a binocular mi-

croscopie after 20 minutes to determine the progress of clearing. 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 to examine and allow drawing of all the necessary details of the species, from all sides. For a better examination of some specific features and more accurate description of the male adult, various taxonomic details in particular the hypopygium, was illustrated in a lateral view separately with anal point and tergite IX omitted to facilitate proper illustration of some relevant taxonomic characters. Remaining parts of the abdomen and the halteres are preserved in 85–90% ethanol for potential DNA analysis. Morphological terminology and measurements follow those of Sæther [1980] and Langton, Pinder [2007] for the imagines and Sæther [1980] and Langton [1991] for the pupal exuviae.

Type specimens are deposited in the collection of Musée cantonal de Zoologie, Palais de Rumine, 6 place de la Riponne, CH-1014 Lausanne, Switzerland (MZL), and personnel depositarium of J. Moubayed (JM).

Systematics

The genus *Bryophaenocladus* Thienemann, 1934: Generic diagnosis for known male adult from southern Europe and North-Africa

On the basis of some additional characters of the genus *Bryophaenocladus*, a complemented generic diagnosis of the male adult is briefly highlighted according to previous data from the literature as documented in: Cranston et al. [1989]; Wang et al. [2001, 2006]; Makarchenko, Makarchenko [2006, 2009, 2012]; Langton, Pinder [2007]; Ding et al. [2011]; Donato [2011]; and Moubayed, Lods-Crozet [2022].

Head. Antenna with or without pre-apical stout seta; palpomere 3 with or without apical projection, sensilla coeloconica occasionally present; clypeus broadly sub-rectangular to sub-trapezoidal, with 1 to numerous setae.

Thorax. Anteprenotum well-developed, lobes gaping or fused, occasionally sinuous; acrostichals present or absent, often decumbent and biserial, usually robust, long, beginning close to anterior margin of scutum. Membrane of wing with coarse punctuation.

Legs with sensilla chaetica on tibiae and tarsomeres ta_1 – ta_5 .

Abdomen. Tergites VII–VIII with or without anteromedian whitish spots; tergite IX often with a dorsal hump (only occasionally absent); anal tergite bands present or absent, often located close to antero-lateral or postero-lateral margins and provide useful specific characters. Anal point with or without lateral expansions, dorsal setae in high to low number, scle-

rotization present or absent at base and lateral basal margins. Virga present or absent, when present it consists of short to long spines, pin, comma or horse-shoe-shaped spines. Phallapodeme well-developed, basal expansion pointed or spatulate, curved inwardly or straight; aedeagal lobe small to large swollen plate-like. Gonocoxite with truncate or rounded apex; basal junction with or without pars ventralis; superior volsella strongly to weakly swollen. Inferior volsella with one or two lobes; dorsal one digitiform, lobe to nose-like, sub-triangular to sub-rectangular, inversed L-shaped, posterior lobe well to weakly-developed (thus easily overlooked); ventral marsupial pouch-like to bulging; inner part of gonocoxite often with a characteristic 'setiferous dorsal area', which consists of 3 specific combination of characters. Gonostylus well-developed, often with posterior projection, linearly elongate or semi-circular, anterior side with numerous setae, posterior part often hyaline with partly bare margin; crista dorsalis present or absent, when present, consisting of a broad lobe occupying partly or entirely the anterior edge (occasionally with numerous characteristic undulations).

Description of new species

Bryophaenocladus poneli

Moubayed et Langton, sp.n.

Figs 1–11 (male adult); 12–19 (male pupal exuviae).

<http://zoobank.org/NomenclaturalActs/6723EE86-FF34-49EC-A89C-1EF6AC39C635>.

= *Bryophaenocladus* sp. 1: Moubayed-Breil [2020];

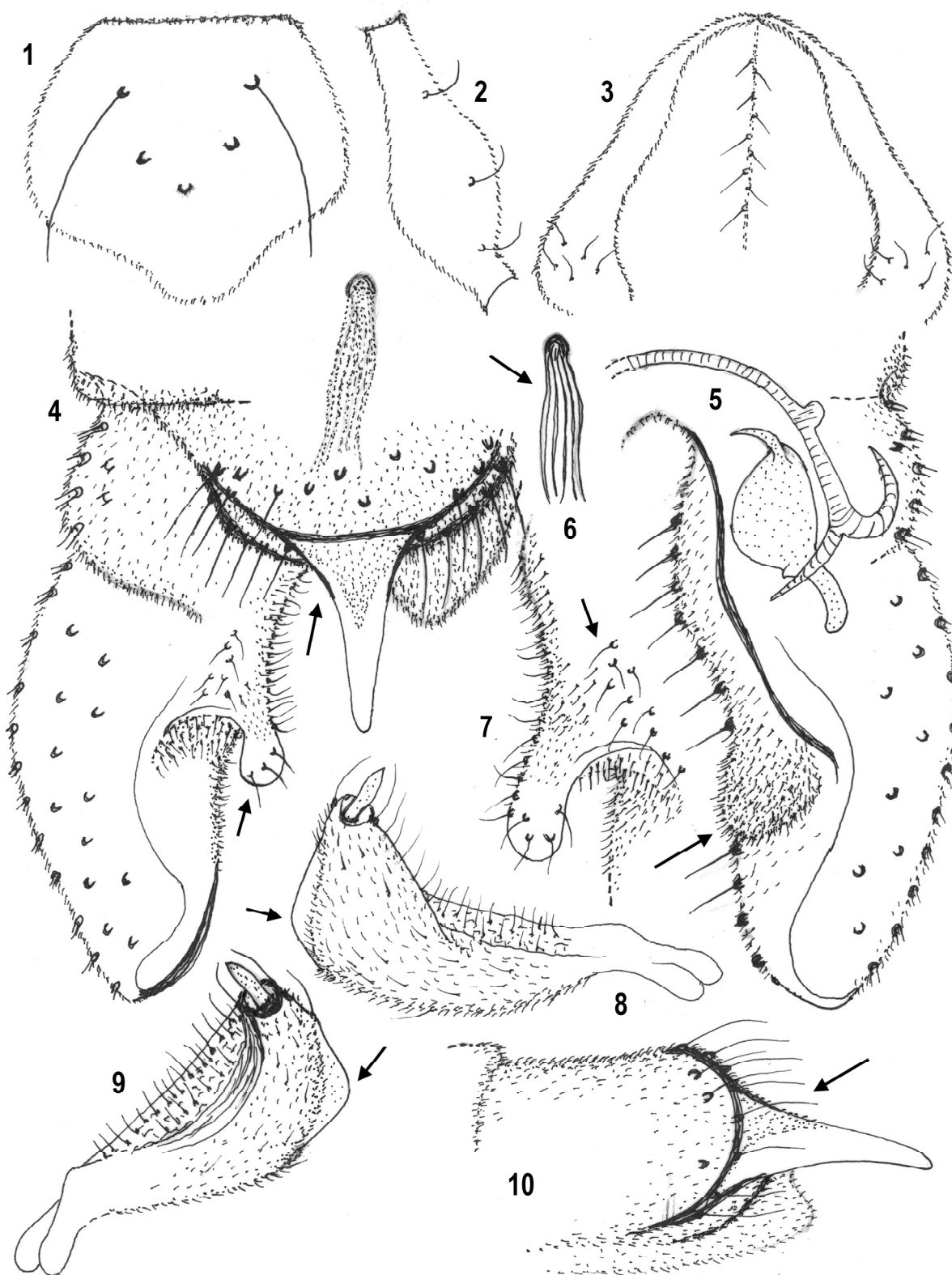
= *Bryophaenocladus* sp. 3: Moubayed-Breil, Ashe [2016].

Material. Continental France, Eastern-Pyrenees: Holotype, male pharate adult, Soques glacial springs and stream, Mantet Nature Reserve, h-2000–2200 m a.s.l.; 42°28'38" N, 02°18'26" E; leg. J. Moubayed, 08.VIII.2008, the male adult and its associated pupal skin, mounted on 1 slide (MZL). Environmental data of water are: crystalline water, conductivity (Cd) 20–25 μ S/cm; temperature (T °C) 6.5–8.0 during late spring, 9–12 during late summer; pH acid, 5.1–5.5. Paratype: idem, 1 male adult, same locality and data as for holotype, leg. J. Moubayed (JM).

Description. Male adult. Small: total length 2.45 mm. Wing length 1.65 mm. General colouration pale brown to dark brown. Head, thorax and apodemes dark brown; abdomen brownish, anal segment contrasting from pale brown to dark brown, posterior part of tergite IX and base of anal point with characteristic blackish bands.

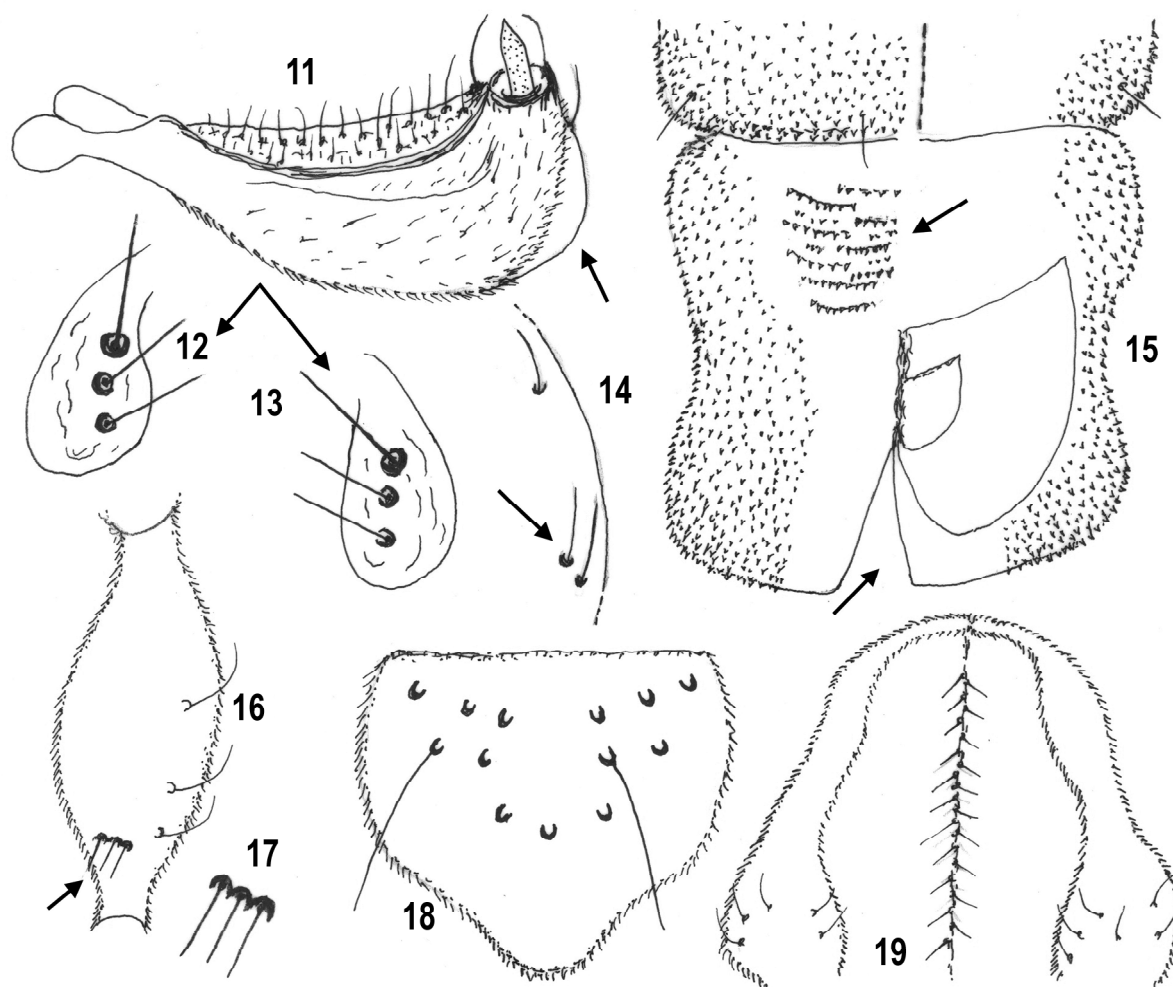
Head. Eyes bare. Frontal area without tubercles; margins of vertex thinner at base; temporals 8 including 5 inner and 3 outer verticals. Antenna 13-segmented, 825 μ m long, last flagellomere 370 μ m long, AR 0.81; antennal groove reaching segment 3. Clypeus (Fig. 1) 5-segmented, sub-trapezoidal, with 5 setae in 3 rows. Palp 5-segmented, palpomere 3 (Fig. 2) with 3 sensilla clavata, sensilla coeloconica absent; length (in μ m) of segments: 25, 35, 90, 95, 125.

Thorax. Anteprenotum (Fig. 3) well developed, anteprenotal lobes in contact, not gaping, dorsal part distinctly thinner and slightly pointed, lateral anteprenotals 5; acrostichals 11 in 1–2 rows, starting close to anteprenotum; dorsocentrals consist of 7 decumbent setae in 1 row; prealars 4, about 100 μ m long; humeral pit absent; supraalars absent; scutellum with 6 uniserial setae (3 on each side of the midline). Wing. Brachi-



Figs 1-10. Male adult of *Bryophaenocladus poneli* sp.n. 1 — clypeus; 2 — palpomere; 3 — lobes of anteprepronotum; 4-5 — hypopygium in dorsal and ventral view; 6 — virga; 7 — inferior volsella, right side; 8-9 — gonostylus at right and acute angle; 10 — tergite IX and anal point, lateral. Here and in all other figures arrows indicate some distinguishing characters.

Рис. 1-10. Имаго самец *Bryophaenocladus poneli* sp.n. 1 — клипеус; 2 — 3-й членок максиллярного щупика; 3 — доли переднеспинки; 4-5 — гипопигий сверху и снизу; 6 — вирга; 7 — нижний придаток гонококситы, справа; 8-9 — гоностиль под прямым и тупым углом; 10 — тергит IX и анальный отросток, сбоку. Здесь и на всех остальных рисунках стрелки указывают на некоторые отличительные признаки.



Figs 11–19. Male adult and pupal exuviae of *Bryophaenocladius poneli* sp.n. (11–15) and *B. righettii* sp.n. (16–19). 11 — gonostylus, lateral; 12–13 — precorneal setae; 14 — dorsocentral setae; 15 — segment VIII and anal lobe; 16–17 — palpomere 3 and sensilla coelconica; 18 — clypeus; 19 — lobes of antepronotum.

Рис. 11–19. Имаго самец и экзувий куколки *Bryophaenocladius poneli* sp.n. (11–15) и *B. righettii* sp.n. (16–19); 11 — гоностиль; 12–13 — прекорнеальные щетинки; 14 — дорсоцентральные щетинки; 15 — сегмент VIII и анальная лопасть; 16–17 — 3-й членик максиллярного щупика и кольцевой орган; 18 — клипеус; 19 — доли переднеспинки.

olum with 1 seta; subcosta reaching fork of radius; costal expansion 30 μ m long. Membrane with coarse punctuation; distribution of setae on veins: R, 11; R₁, 1–2; remaining veins bare; squama with 4 short setae in 1 row.

Legs. Sensilla chaetica on: tibia and tarsomeres ta₁–ta₅ of PI; tibia and tarsomeres ta₁–ta₄ of PII–PIII. Length (in μ m) and proportions of leg segments as in Table 1.

Abdomen. Hypopygium in dorsal and ventral view as in Figs 4–5; ventral view (Fig. 5) with tergite IX and anal point omitted. Tergite IX (Fig. 4) broadly sub-rectangular at base, nearly semi-circular distally; anal lateral tergite band on distal

half, interrupted at base; 8–9 setae present laterally, close to the posterior margin. Sternite VIII with 12 lateral setae (6 on each side). Anal point (Figs 5, 10; 5 dorsal; 10 lateral) 70 μ m long, 85 maximum width; broadly triangular, with rounded apex, lateral expansions absent, basal and lateral margins with characteristic sclerotization. Virga consists of 5–6 long spines, about 85 μ m long. Transverse sternapodeme rounded, lateral sternapodeme short. Phallapodeme well-developed, aedeagal lobe distinctly swollen. Gonocoxite (Figs 4–5) 225 μ m long, 80 μ m maximum width, truncate apically; dorsal side (Fig. 4) lacking distal inner tubercle; ventral side (Fig. 5) with scleroti-

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

	fe	ti	ta ₁	ta ₂	ta ₃	ta ₄	ta ₅	LR	BV	SV	BR
PI	680	815	475	285	235	115	100	0.58	2.68	3.15	1.60
PII	820	925	385	225	170	105	90	0.42	5.84	4.53	2.30
PIII	745	790	425	265	210	110	95	0.54	4.72	3.61	2.40

zation, inner margin with 12–13 stout setae. Superior volsella (Fig. 7) a wide large lobe. Inferior volsella (Figs 4, 7), double; dorsal part digitiform about 50 µm long, distal part 30 µm long, 15 µm maximum width at apex, apical part spatulate with 3–4 short setae, proximal and distal part of setiferous inner area bare, only median part covered with setae; ventral part marsupial pouch to bulging, densely covered with microtrichia. Gonostylus (Figs 8–9, 11) about 75 µm long and 25 µm maximum width, with posterior projection, anterior side covered with short and long fine setae; posterior angle bare, clearly visible at right and acute angle and in lateral view as in Figs 8–9, 11; crista dorsalis absent; megaseta well-developed. $HR = 3.0$. $HV = 3.27$.

Male pupal exuviae. Abdomen and anal segment entirely pale to transparent, anteprenotal and precorneal areas brownish. Total length 2.55 mm. Frontal apotome not domed, frontal tubercles and frontal setae absent. Anteprenotum characteristically unarmed, anteprenotals subequal (115–120 µm long); precorneals (Figs 12–13) consist of 1 long and 2 shorter subequal setae (115 and 75 µm long); dorsocentrals (Fig. 14) subequal, about 3.5 µm long, Dc_1 and Dc_2 separated by 135 µm while Dc_2 and Dc_3 are closely inserted. Abdomen chaetotaxy and distribution pattern of shagreen, spinules and points of abdominal segments as figured in Pankratova [1970: 147, Figs 6–7], Coffman et al. [1986: Fig. 9.7] and Langton [1991: Fig. 69a]. Tergite II–VIII with dense field of points. Anal lobe (Fig. 15) about 250 µm long and 225 µm maximum width, less wide medially; both proximal and distal parts laterally expanded; apical margin distinctly truncate; macrosetae absent; genital sac about 135 µm long, not reaching posterior margin of anal lobe.

Female adult and Larva unknown.

Diagnostic characters. According to the recently emended generic diagnosis of the genus *Bryophaenocladius* [Moubayed, Lods-Crozet, 2022] and other additional morphological data provided by Pankratova [1970], Langton [1991], Makarchenko, Makarchenko [2006, 2009, 2012], Langton, Pinder [2007], both male adult and pupal exuviae of *B. poneli* sp.n. appear to belong to the combined 2 groups of species: *nitidicollis*- and *ictericus*-groups. However, the male adult and its pupal exuviae are easily separated by a combination of characters.

Male adult. Head. Antenna 825 µm long, last flagellomere 370 µm long, AR 0.81; clypeus trapezoidal, with 5 setae; palpomere 3 without apical projection. Thorax. Lobes of anteprenotum not gaping, dorsally thin and pointed; acrostichals 9 in 1–2 rows; scutellum with 6 setae. Wing. Squama with 4 setae. Abdomen. Lateral sclerotized bands of tergite IX close to the posterior lateral margins, are interrupted towards the base. Anal point broadly triangular, without lateral expansions, basal and lateral margins with characteristic sclerotization. Virga composed of 5–6 long spines. Sternapodeme not projecting; phallapodeme well-developed, aedeagal lobe swollen. Gonocoxite truncate apically; dorsally and ventrally with fine sclerotization, ventral inner margin with 12–13 stout setae. Inferior volsella double, dorsal side digitiform to long nose-shaped, spatulate apically and bearing short apical setae; ventral side marsupial pouch-shaped to rounded; only median part of setiferous inner area is covered with short setae, proximal and distal parts bare. Gonostylus with posterior projection, caudal margin partly bare distally; crista dorsalis absent.

Pupal exuviae. Anteprenotum atypically smooth, anteprenotals 2, subequal; thoracic horn absent; precorneals consist of 1 long thick seta (35 µm long) and 2 thinner (25 µm long); dorsocentrals sub-equal, distance between Dc_1 and Dc_2 130 µm.

Abdomen belongs to *Bryophaenocladius*-type; tergite I with 2 anteromedian groups of points; anal lobe wider in proximal and distal parts, apical part typically truncate; macrosetae absent; genital sac of male not reaching tip of anal lobe.

Etymology. This species is named *poneli* in honour of Philippe Ponel, who remains active as senior researcher at CNRS of the Mediterranean Institute for Marine and Terrestrial Biodiversity and Ecology (IMBE, Aix-Marseille University). He keeps working as entomologist on terrestrial and aquatic Coleoptera contributing to preservation of their habitats and their biodiversity in France.

Remarks. **Male adult.** Although some common characters are observed between the male adult of *B. poneli* sp.n. and that of *B. aestivus* (Edwards, 1929) and *B. nitidicollis* as figured in Brundin [1947: Fig. 56], Langton, Pinder [2007: Figs 140 (B), 138 (D)], Du et al. [2011: Fig. 1] and Makarchenko, Makarchenko [2006: Fig. 25], the following differentiating atypical characters will separate the new species from its congeners: — tergite IX and anal point with anal tergite bands (Fig. 4); — virga consisting of several long spines (Figs 4, 6); — inferior volsella double, dorsal part digitiform with spatulate apex (Figs 4, 7), ventral part broadly lobed to marsupial pouch-shaped (Fig. 5).

Male pupal exuviae. Based on some common morphological similarity, the closest species to *B. poneli* sp.n. are *B. aestivus*, *B. ictericus* (Meigen, 1830) and *B. nitidicollis* (Goegebeuer, 1913) as documented in Strenzke [1957: Figs 6–7], Pankratova [1970: Figs 151(3), 152(7)] and Langton [1991: Fig. 70 (k, n)]. However, the pupal exuviae of *B. poneli* p.n. is separable by the following combination of characters: — anteprenotum characteristically unarmed; — precorneals 3 including 1 long and 2 shorter (Figs 12–13); — anal lobe subrectangular with apical margins truncate (Fig. 15).

Bryophaenocladius righettii Moubayed et Langton, sp.n.

Figs 16–25.

<http://zoobank.org/NomenclaturalActs/56342784-3479-417A-B142-AF244BFB82C1>.

Material. **Continental S-France, Cèvennes:** *Holotype:* male adult, Barrandon cold stream, Cévennes National Park, Lozère Department, h-1385 m a.s.l., 44°27'18" N, 3°37'00" E, 03.X.2017, leg. G. Coppa, the holotype mounted on 1 slide (MZL). Environmental data of water are: crystalline water, conductivity (Cd) 13–15 µS/cm; T (°C) 4–8 during late winter, 8–12 during late summer; pH acid, 5–6. *Paratype:* 1 male adult, leg. G. Coppa, same locality and date as for holotype (JM).

Description. **Male adult.** Large: total length 3.55 mm. Wing length 1.85 mm; TL/WL 1.92. General colouration from brown to blackish; head blackish, antenna brown; thorax brown with blackish mesonotal stripes; legs uniformly brown; abdomen brownish, anal segment with characteristic blackish fine bands at base of anal point.

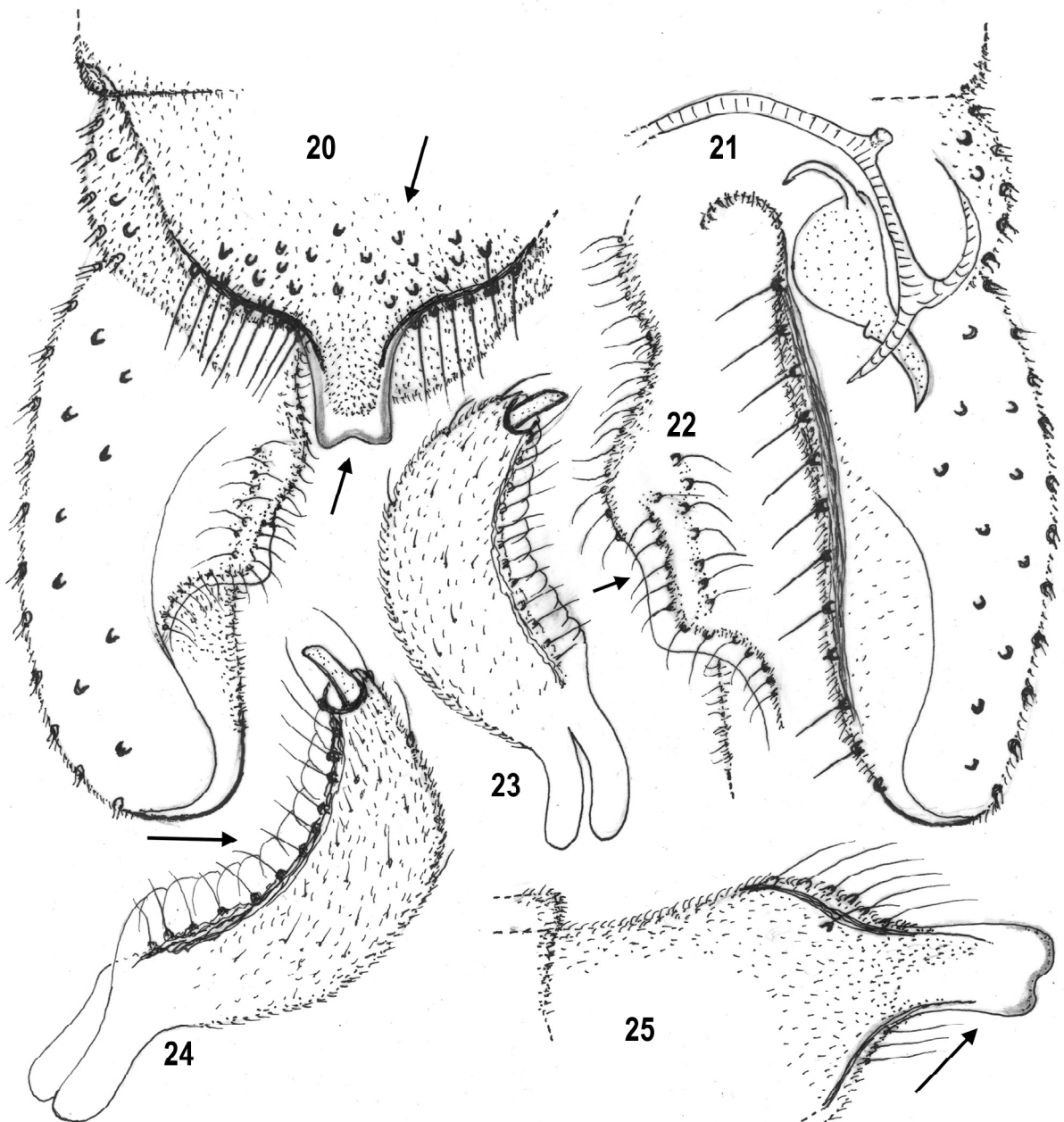
Head. Frontal area with 1 median tubercle; temporals 11 including 8 inner and 3 outer verticals. Antenna 13-segmented, 1320 µm long; last flagellomere 260 µm long, with 1 stout pre-apical seta; AR 0.61; antennal groove reaching segment 3. Palp 5-segmented, palpomere 3 (Figs 16–17) lacking apical projection, with 3 sensilla clavata and 3 sensilla coeloconica. Clypeus (Fig. 18) 85 µm long, 95 µm maximum wide, subrectangular, with 7–8 setae.

Thorax. Lobes of anteprenotum (Fig. 19) not gaping and thinner dorsally; anteprenotals 5–6; 21 long acrostichals (100–110 µm long) in 1–2 row, starting close to anterior margin of scutum; dorsocentrals composed of 21 decumbent setae in 1–2 rows; prealars 6 uniserial; humeral pit without granulation;

scutellum with 6 uniserial strong setae. *Wing*. Brachiolium with 1 seta; subcosta extending beyond fork of radius; costal expansion short, about 2–3 μm long. Membrane with coarse punctuation; distribution of setae on veins: R, 14; R_1 , 6; R_{4+5} , 11–13; remaining veins bare; squama with 6 setae. *Legs* (length in μm). Tibial spurs on: PI (1, 60), PII (2, 80, 30), PIII (2, 70, 35); pseudospurs on tibia and tarsomeres ta_1 – ta_3 of PII–PIII. Tibia and tarsomeres ta_1 – ta_5 of PI–PIII densely covered with sensilla chaetica. Length (in μm) and proportions of leg segments as in Table 2.

Abdomen. Hypopygium in dorsal and ventral view as in Figs 20–21, ventral view (Fig. 21) with tergite IX and anal

point omitted. Tergite IX 95 μm maximum width, broadly subrectangular at base, slightly narrowing distally; dorsal hump weakly projecting as illustrated in lateral view (Fig. 25); tergite sclerotized bands located close to the posterior lateral margins. Sternite VIII with 16 lateral setae (8 on each side). Anal point (Figs 20, 25) 60–65 μm long, 110 μm maximum width, with 31–33 setae located on lateral and basal area, lateral expansions absent; broadly cylindrical, parallel-sided and distinctly forked apically as in dorsal (Fig. 20) and lateral (Fig. 25) view; proximal and median areas covered with microtrichia (distal part bare); fine linear sclerotization restricted to the basal lateral margins, abruptly interrupted in its anteromedian part.



Figs 20–25. Male adult of *Bryophaenocladus righettii* sp.n. 20–21 — hypopygium in dorsal and ventral view; 22 — inferior volsella, right side; 23–24 — gonostylus in acute and right angle view; 25 — tergite IX and anal point, lateral.

Рис. 20–25. Имаго самца *Bryophaenocladus righettii* sp.n. 20–21 — гипопигий сверху и снизу; 22 — нижний придаток гоноксита, справа; 23–24 — гоностиль под прямым и тупым углом; 25 — тергит IX и анальный отросток, сбоку.

Table 2. Lengths (in μm) and proportions of leg segments of *Bryophaenocladus righettii* sp.n., male ($n = 1$)
Таблица 2. Длина (в μm) и пропорции члеников ног самца *Bryophaenocladus righettii* sp.n. ($n = 1$)

	fe	ti	ta ₁	ta ₂	ta ₃	ta ₄	ta ₅	LR	BV	SV	BR
PI	870	1045	665	390	305	195	145	0.64	2.49	2.88	1.45
PII	955	920	510	260	195	175	115	0.55	3.20	3.67	2.50
PIII	970	1115	610	325	260	160	140	0.55	3.05	3.41	2.30

Virga absent. Transverse apodeme rounded, not projecting orally. Phallapodeme and aedeagal lobe well-developed, basal expansion pointed at base. Gonocoxite (Figs 20–21) 250 μm long, 95 μm maximum width, slightly truncate apically, distal inner tubercle absent; dorsal side as in Fig. 20, only median and distal parts of setiferous inner area (Figs 20, 22) are covered with setae; ventral side with a fine longitudinal sclerotization located close to the inner margin, inner margin with 12 stout setae. Inferior volsella (Figs 20, 22) a right angled lobe, with smooth inner apical margin. Gonostylus (Fig. 23, acute angle; Fig. 24 right angle) 120 μm long, 40 μm maximum width, posteriorly projecting; anteriorly entirely covered with long setae placed along 1 row; posteriorly nearly semi-circular lacking bare margin; crista dorsalis well-developed, consists of numerous characteristic undulations extending along the entire anterior side; megaseta well-developed. HR = 2.08, HV = 2.96.

Female adult, pupal exuviae and larva unknown.

Diagnostic characters. On the basis of some atypical characters found in the male adult (antenna with 1 pre-apical seta; anal point cylindrical and forked apically; inferior volsella inversed L-shaped, only median part of setiferous area covered with setae; crista dorsalis with characteristic undulation), *B. righettii* sp.n. keys close to its likely sister European species *B. femineus* Edwards, 1929. However, *B. righettii* sp.n. can be separated by the following distinguishing characters.

Head. Frontal area with 1 median semicircular tubercle; temporals 13. Antenna 685 μm long, last flagellomere with 1 pre-apical seta, AR 0.61; palpomere 3 with 3 sensilla coeloconica. **Thorax.** Lobes of antepnotum not gaping and thinner at base; acrostichals composed of 21 long setae; scutellum with 6 uniserial setae. **Wing.** Squama with 6 setae. **Legs.** Tibia and tarsomeres ta₁–ta₅ of PI–PIII densely covered with sensilla chaetica. **Abdomen.** Tergite IX sub-rectangular, tergite bands restricted to the caudal lateral margins. Anal point parallel-sided and broadly cylindrical, with a characteristic forked apex; lateral expansions absent; fine sclerotized bands restricted to the basal lateral margins, interrupted at base and extending to its proximal half; anteromedian part covered with microtrichia, distal part bare. Virga absent. Phallapodeme and aedeagal lobe well-developed, basal expansion pointed. Gonocoxite with rounded apex; distal dorsal tubercle absent. Superior volsella broad lobe-like. Inferior volsella L-shaped, swollen and sinuous in its proximal part, with right angled apex; setiferous inner area with 2 characteristic rows of setae on proximal and median parts, proximal row longitudinally elongate, distal row sinuous, extending downwards along caudal part of inferior volsella. Gonostylus not projecting posteriorly, anterior side covered with long setae in 1 row, the posterior margin rounded; crista dorsalis well-developed, composed of numerous characteristic undulations occupying 100 % of the anterior side.

Etymology. The new species is named *righettii* in honour of Bruno Righetti, who remains active as entomologist in studying aquatic insects. He keeps working in particular on Ephemeroptera of France, contributing to preserve their habitats and their biodiversity.

Remarks. *Male adult.* Though *B. righettii* sp.n. resembles *B. femineus* as figured in Langton, Pinder [2007: Fig. 139 (B)], the following distinguishing characters will easily separate it from other related congeners. Anal tergite bands on posterior lateral margins of tergite IX extending towards proximal half of anal point; anal point broadly cylindrical with forked apex (Figs 20, 25), basal part lacking sclerotization; inferior volsella sub-rectangular; only median and distal parts of setiferous area covered with setae; basal expansion of phallapodeme arched and pointed (Fig. 21); crista dorsalis long, with characteristic undulations.

Bryophaenocladus vosgensis
Moubayed et Langton, sp.n.

Figs 26–37.

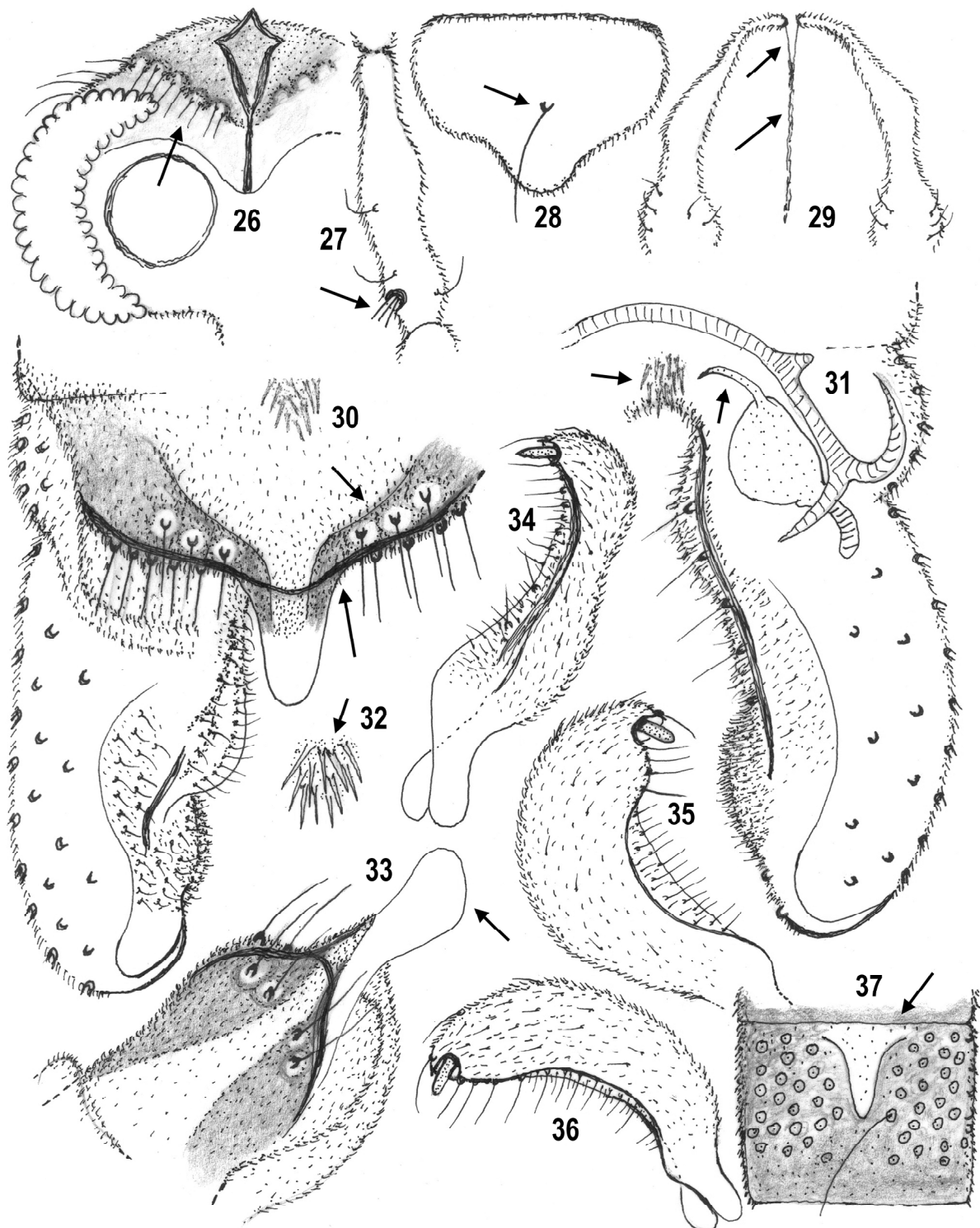
<http://zoobank.org/NomenclaturalActs/8033748A-7359-4E37-9B56-32EE39AC8F4C>.

Material. Continental NE-France, Vosges region: *Holotype*, 1 male adult, Acid peat bogs of Machais Nature Reserve, h - 980–1000 m a.s.l.; 48°02'24" N, 06°57'34" E; 22.V.2020, leg. Jocelyn Claude, the male holotype mounted on 1 slide (MZL). Environmental data of water are: crystalline water, conductivity (Cd) 8–28 $\mu\text{S}/\text{cm}$; T (°C): 1–4 during late winter, 8–12 during late summer; pH acid, 5–6. *Paratypes*: idem, 5 male adults, same locality and same environmental data as for holotype, 1 paratype on 1 slide (MZL), 4 paratypes (JM).

Description. *Male adult.* Large: total length (TL) 4.60 mm. Wing length (WL) 2.65 mm; TL/WL = 1.74. General colouration contrasting pale brown to dark brown-blackish especially on the thorax. Head dark brown to blackish, antenna pale brownish; thorax contrasting brown to dark brown with blackish mesonotal stripes, scutellum brownish with blackish margins; legs uniformly brownish; abdomen brownish, anteromedian part of tergite VIII (Fig. 37) with a characteristic whitish conical spot; anal segment contrasting from pale brown to dark brown, bearing characteristic blackish tergite anal bands.

Head (Fig. 26). Eyes bare. Frontal tubercles absent; vertex with a triangular median tubercle (Fig. 26); coronal setae absent; temporals 11 including 9 inner and 2 outer verticals, inner verticals with characteristic decumbent setae inserted in circular or oval base. Antenna 13-segmented, 1.320 μm long, last flagellomere 800 μm long, AR 1.54; antennal groove beginning on segment 2. Palp 5-segmented, length (in μm) of segments: 45, 55, 125, 100, 135 (segment 4 occasionally shorter than segment 3; palpomere 3 (Fig. 27) with 3 sensilla clavata, posterior part with 3 sensilla coeloconica. Clypeus (Fig. 28) 100 μm long, 150 μm maximum width, sub-trapezoidal, atypically with only 1 seta.

Thorax. Antepnotum well-developed, antepnotal lobes (Fig. 29) not gaping, separated dorsally and sinuous, lateral antepnotals 5; acrostichals atypically absent; dorsocentrals 10–13 in 1 row; prealars 5–6 in 1 row; Humeral pit half ellipsoid, with granulation; scutellum with 6 uniserial setae. **Wing.** Brachiolium with 1 seta; subcosta extending beyond fork of radius, costal expansion about 70–80 μm long. Membrane with coarse punctuation; distribution of setae on veins: R, 12–14; remaining veins bare; squama with 4 short setae of 3–5 μm long. **Legs.** Tibial spurs of: PI 85 μm long, PII–PIII 50,



Figs 26–37. Male adult of *Bryophaenocladus vosgensis* sp.n. (26–37). 26 — head, left side in dorsal view; 27 — palpomere 3; 28 — clypeus; 29 — lobes of antepnotum; 30–31 — hypopygium in dorsal and ventral view; 32 — virga; 33 — tergite IX and anal point, lateral; 34–35 — gonostylus at acute and right angle; 36 — gonostylus, lateral; 37 — tergite VIII.

Рис. 26–37. Имаго самец *Bryophaenocladus vosgensis* sp.n. 26 — голова, слева и сверху; 27 — 3-й членок максиллярного щупика; 28 — клипеус; 29 — доли переднеспинки; 30–31 — гипопигий сверху и снизу; 32 — вирга; 33 — тергит IX и анальный отросток, сбоку; 34–35 — гоностиль под тупым и прямым углом; 36 — гоностиль, сбоку; 37 — тергит VIII.

40 and 75, 40; pseudospurs present on ta_1 – ta_3 of PII–PIII. Sensilla chaetica present on: tibia and tarsomeres ta_1 – ta_3 of PI–PIII. Length (μ m) and proportions of leg segments as in Table 3.

Abdomen. Hypopygium in dorsal and ventral view as in Figs 30–31; ventral view (Fig. 31) with tergite IX and anal point omitted. Tergite IX broadly sub-rectangular; posterior margin nearly straight; anal tergite bands extending caudally close to the posterior margin and along the basal part of anal point; anteromedian part bare, delimited by 2 lateral large dark areas extending to proximal half of anal point. Anal point (Fig. 30, dorsal; Fig. 33, lateral) about 70 μ m long, 40 μ m maximum width at base, broad triangular and slightly narrowing distally; markedly spatulate when viewed laterally as in Fig. 33; basal part with 6 characteristic decumbent setae (3 on each side of the midline); lateral margins with 8–9 setae located laterally (4–5 on each side); proximal half densely covered with microtrichia, distal half bare. Sternite VIII with 14 lateral setae (7 on each side). Virga (Figs 30–32) well-developed, of 9–11 divergent spines. Transverse sternapodeme slightly projecting, lateral expansion pointed. Phallapodeme well-developed, basal expansion pointed, aedeagal lobe broadly swollen. Gonocoxite (Figs 30–31) 265 μ m long, 125 μ m maximum width, rounded apically, distal tubercle absent; dorsally (Fig. 30) with proximal, median and distal parts of setiferous inner area covered with setae; ventral side (Fig. 31) with 11–12 stout setae. Superior volsella (Fig. 31) broadly expanded. Inferior volsella (Fig. 30), about 15–20 μ m long, 5 μ m maximum width; broad inversed L-shaped, proximal and distal margins smooth; apical part roundly bulging to angular, strongly turned inwards posteriorly; proximal, median and distal parts of setiferous inner area covered with setae; distribution pattern of setae: is longitudinal in proximal part and grouped in median and posterior parts. Gonostylus (Figs 34–36) about 150 μ m long, 35 μ m maximum width, without posterior projection, linearly elongate at acute angle (Fig. 34), semi-circular at right angle and lateral view (Figs 35–36); anteriorly covered with numerous long and short setae; crista dorsalis absent; megaseta well-developed. HR = 1.77, HV = 3.07.

Female adult, pupal exuviae and larva unknown.

Diagnostic characters. **Head.** Frontal tubercles absent; vertex with a basal triangular expansion; temporals include partly decumbent inner verticals; antenna 1320 μ m, AR 1.54; clypeus sub-rectangular, atypically with only 1 seta; palpomere 3 not projecting apically, with 3 sensilla coeloconica. **Thorax.** Lobes of antepronotum not gaping, sinuous and slightly separated dorsally; acrostichals absent as in *B. psilacrus* Sæther, 1982. Wing 2.65 mm long, squama with 2–4 short setae of 3–5 μ m long. **Abdomen.** Tergites with numerous decumbent setae, tergite VIII (Fig. 37) with a characteristic anteromedian conical whitish spot. Tergite IX sub-rectangular, median part whitish and bare, laterally with 2 characteristic dark spots, progressively decreasing in width posteriad and reaching midline of anal point; anal tergite band thin, present antero-medially; posterior margin with 9–10 lateral setae (4–5 located on each side of the anal point). Sternite VIII with 14 lateral setae (7 on each side). Anal point broadly triangular with rounded

apex, gradually narrowing distally, spatulate when viewed laterally; lateral expansions absent; basal area with 6 characteristic decumbent setae (3 on each side of the midline); distal half bare. Virga well-developed of 10–11 divergent thin spines. Phallapodeme with pointed basal expansion, aedeagal lobe swollen. Gonocoxite rounded apically, lacking distal tubercle. Superior volsella swollen. Inferior volsella double: dorsal part broad inversed L-shaped with rounded apex, numerous short setae in 1 row along the inner proximal margin; proximal, median and distal parts of setiferous inner area covered with setae; ventral part broadly expanded, densely covered with short setae. Gonostylus not projecting posteriad, linearly elongate at acute angle, nearly semi-circular in lateral view; anteriorly with numerous long and short setae; crista dorsalis absent.

Etymology. The species name «*vosgensis*» refers to the Vosges region (NE-France), which geographically covers large mountainous areas including cold springs and streams, wet meadows, lakes and acid peat bogs.

Remarks. *Male adult.* The closest species to *B. vosgensis* sp.n. is *B. piltunensis* Makarchenko et Makarchenko, 2006. These 2 species can be separated easily by the following differentiating characters: in *B. vosgensis* sp.n. the clypeus with only 1 seta (Fig. 28); lateral anteprenotals 5–6 and acrostichals absent (Fig. 29); squama with 4 short setae; tergite IX contrasting in colour, with 1 anteromedian whitish part and 2 lateral larger darkened areas reaching proximal half of anal point; virga present, consisting of several diverging spines (Figs 30–32).

Ecology and geographical distribution

Male adult and pupal exuviae of *B. poneli* sp.n. and male adults of *B. righettii* sp.n. and *B. vosgensis* sp.n. were collected in bordering aquatic and semiterrestrial habitats delimited by cold glacial helocrenes and cold stenothermic streams. Enriched substratum with submerged and emergent bryophytes, humus, deciduous wood and tree bark, must represent the most favourable microhabitats for their larval populations. Consequently, the three latter new species appear to belong to the crenophilous community of chironomid species as documented by Lindegaard [1995].

Taxonomic remarks

Currently, about 85 known *Bryophaenocladus* species are reported from the Palaearctic Region, of which 37 are known from Europe. Consequently, the description here, of *B. poneli* sp.n., *B. righettii* sp.n. and *B. vosgensis* sp.n. increases the total number in the genus to 40 species recorded from Europe. Currently, 18 *Bryophaenocladus* species are reported from continental France including 3 recently described species by Moubayed, Lods-Crozet [2022]. Therefore,

Table 3. Lengths (in μ m) and proportions of leg segments of *Bryophaenocladus vosgensis* sp.n., male ($n = 1$)
Таблица 3. Длина (в мкм) и пропорции члеников ног самца *Bryophaenocladus vosgensis* sp.n. ($n = 1$)

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
PI	1015	1220	815	455	290	175	120	0.67	5.21	2.74	3.0
PII	1105	1075	555	305	220	140	115	0.52	5.76	3.93	2.85
PIII	1160	1370	790	385	330	170	135	0.58	5.23	3.20	3.40

the description of these 3 new species increases the total number in the genus to 21 from this country. A combination of some morphological distinctive characters found in the male adult are highlighted in the following differential diagnosis, which will separate the 3 new described species from related members of the genus.

Based on the previously provided descriptions, both *B. poneli* sp.n. and *B. vosgensis* sp.n. appear to belong to a local biogeographic element, while *B. righettii* sp. n. shows some common characters, namely with *B. femineus* Edwards, 1929. 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 *Bryophaenocladus* from Europe until sufficient material of all undescribed species has been examined and compared.

Geographical distribution of the three new described species is currently restricted to 3 different biogeographical areas of continental France. *B. poneli* sp.n. and *B. righettii* sp.n. are known from southern and south western France (Eastern-Pyrenees and Căvennes Regions, alt. 1500–2000 m). *B. vosgensis* sp.n. is known only in the Vosges Region located in NE-France (alt. 900–1100 m).

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