

A morphology-based identification key to the *Cognettia* species of the world (Clitellata: Enchytraeidae)

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Abstract

Morphological characters for identification of *Cognettia* species are presented both as a dichotomous key and in table form. Focus is on non-sexual characters, as many species reproduce mainly asexually, and sexually mature individuals can be rare.

Keywords Annelida | *Chamaedrillus*

1. Introduction

The genus *Cognettia* Nielsen & Christensen, 1959 (Clitellata: Enchytraeidae) has 20 described species (Martinsson et al. 2018), with a mainly Holarctic distribution. The taxonomy of the genus has been changing; Martinsson et al. (2015b) split the genus in two and re-established the names *Chamaedrillus* Friend, 1913 and *Euenchytraeus* Bretscher, 1906. The majority of the species were transferred to *Chamaedrillus*. However, a case was submitted to the International Commission on Zoological Nomenclature proposing that *Cognettia* be given precedence over *Chamaedrillus* and *Euenchytraeus* (Schmelz et al. 2015). Recently the Commission decided in favour of the case, giving *Cognettia* precedence over *Chamaedrillus* and *Euenchytraeus* when they are considered synonyms (ICZN 2018). This ruling is followed here and the name *Cognettia* is used for the species previously placed in *Chamaedrillus*. However, *Euenchytraeus* is in this paper still considered a valid genus, separate from *Cognettia*. Martinsson et al. (2017) showed that *Cognettia* and *Euenchytraeus* together with a third genus *Stercutus* Michaelsen, 1888 form a monophyletic group, but the relationship between them

is unresolved. There are also morphological differences between *Euenchytraeus* and *Cognettia*. The former has head nephridia, i.e., a pair of nephridia at septum 2/3, which is unique among enchytraeids.

The type species of *Cognettia* is the well-studied species *C. sphagnetorum* (Vejdovský, 1878), a model species in soil biology, used in studies of e.g. climate change (Briones et al. 1998, Bataillon et al. 2016), forestry (Lundkvist 1983), acidification (Pokarzhevskii & Persson 1995, Šustr et al. 1997), and nutrient mineralization and availability (Abrahamsen 1990, Mira et al. 2002). However, molecular studies (Martinsson & Erséus 2014) have revealed that this species is actually a complex of several species, which do not form a monophyletic group, and the complex has since been revised (Martinsson et al. 2015b). Several *Cognettia* species can be found in high densities, especially in boreal forests, bogs, and other acidic environments (Springett 1970, Lundkvist 1983), and can represent a dominant proportion of the soil fauna. Some *Cognettia* species are also common in streams and other aquatic habitats (e.g., Schenková et al. 2018). Several species in the genus reproduce mainly asexually, and sexually mature specimens are rare (Christensen 1959, Christensen 1961, Springett 1970)

In recent years, new species have been described in the genus (Martinsson et al. 2015b, Martinsson et al. 2015a, Torii 2015, Dozsa-Farkas et al. 2018, Martinsson et al. 2018). Some of these have been separated mainly based on genetic data.

As species of *Cognettia* are commonly found, can dominate the soil fauna, and *C. sphagnetorum* s.l. are used as a model organism, correct identification is crucial. The aim of this paper is to summarise morphological characters useful to identify *Cognettia* specimens to species. The characters are presented both as a dichotomous key and as a table.

2. Material and methods

A combination of original descriptions (Černosvitov 1928, Moszyński 1938, Nurminen 1965, Healy 1975, Dózsa-Farkas 1989, Healy 1996, Christensen & Dózsa-Farkas 1999, Nakamura 2001, Dumnicka 2010, Torii 2015, Dozsa-Farkas et al. 2018, Martinsson et al. 2018), revisions (Nielsen & Christensen 1959, Martinsson et al. 2015b, Martinsson et al. 2015a), keys (Schmelz & Collado 2010) and studies of slide-mounted specimens were used to collect the data. Non-sexual characters are prioritised as many species reproduce mainly asexually, and the sexual organs seems to be very similar in many species and therefore of limited value for the separation of species. As the characters were collected from various sources with different levels of detail in the information provided, in some cases requiring interpretation, it is possible that some characters have been erroneously interpreted, and the given key should be used with some caution.

In the key, pharyngeal glands (=septal glands) refer to the primary glands if not otherwise specified; see section 3 for more details regarding the morphology, and for a good general overview of enchytraeid morphology Schmelz & Collado (2010) is recommended.

The characters used in the key are summarised in Table 1.

3. General morphology of *Cognettia*-species

Members of *Cognettia* can be separated from other enchytraeids based on a combination of the following characters: 2-4 sigmoid chaetae without nodulus per bundle, in one species a few lateral bundles with only one chaeta, in two species chaetae in some anterior lateral bundles are enlarged. Brain incised posteriorly. 3-6 pairs of pharyngeal glands (=septal glands), in several species well developed secondary glands, i.e., a second pair of separate glands in the same segments (Fig. 1A), and/or ventral lobes i.e., anterior projections of the ventral part of the primary glands, which are still connected with the rest of the gland, are present (Fig. 1B). Oesophageal appendages and intestinal diverticula are missing. No nephridia at septum 2/3, nephridia with anteseptale consisting only of a funnel, nephridial duct arising anteriorly, close to septum (Fig. 1A). Spermatheca free, not attached to oesophagus, often with an ampulla divided into two chambers (Fig. 1D), and with an ectal gland, but in some species the ampulla has only one chamber (e.g., Fig. 1C), ectal gland sometimes missing, or there is an ectal swelling basally on the spermathecal duct (Fig. 1C). Not fully developed spermathecae have an undivided

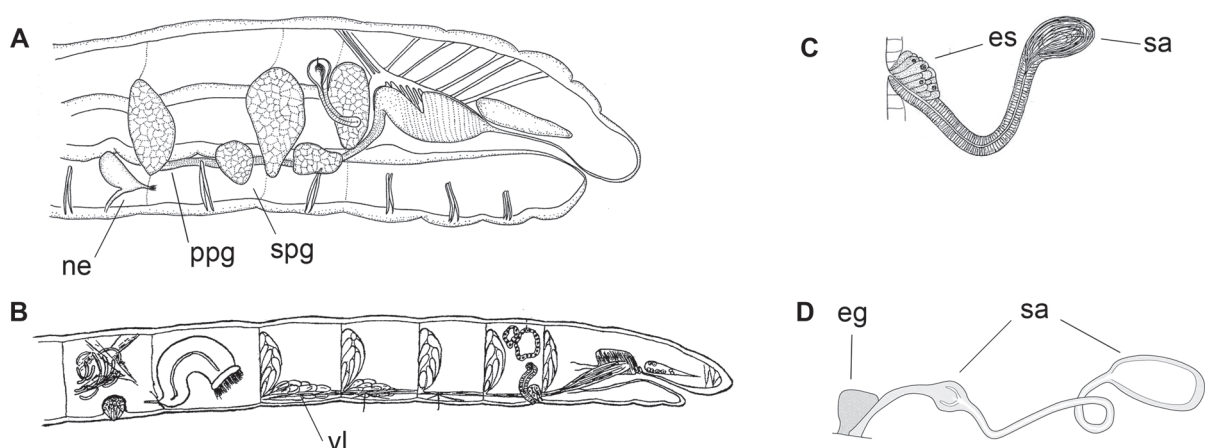


Figure 1. Morphological characters in *Cognettia* species. (A) *C. ozensis*, anterior part, lateral view, showing nephridium (ne), and pharyngeal glands with primary pharyngeal glands (ppg), secondary pharyngeal glands (spg) (modified from Torii 2015). (B) *C. anomala* anterior part, lateral view, showing pharyngeal glands with ventral lobes (vl) (modified from Černosvitov 1928). (C) *C. floridae*, spermatheca, with ectal swelling (es), and one chamber in the spermathecal ampulla (sa) (modified from Healy 1996). (D) *C. glandulosa* spermatheca of the standard *Cognettia*-type, with an ectal gland (eg) and two chambers in the ampulla (modified from Martinsson et al. 2015a).

Table 1. Morphological comparison of *Cognettia* species. Question marks (?) indicate that a description of the character has not been found, or in cases where a species has been split it is not clear which species the description refers to.

| Species | Chaetal formula | Enlarged lateral chaeta | Pairs of pharyngeal glands | Fused pairs of pharyngeal glands | Ventral lobes | Well-developed secondary glands | Arising of dorsal blood vessel | Position of male pores | Chambers in spermathecal ampulla | Ectal gland | Position of first nephridium |
|---|------------------------------------|--|----------------------------|----------------------------------|---------------|---------------------------------|--------------------------------|------------------------|----------------------------------|--------------------|------------------------------|
| <i>C. cognettii</i> (Issel, 1905) | 2,(3)-2:3-3 | 2-3 lateral bundles in (III) V-VII, with 2 enlarged chaetae... | 3 | 3 | 0 | 3 | XIV | XII | 2 | present | 6/7 |
| <i>C. hayachinensis</i> Nakamura, 2001 | 1,3,4,5-3,4,5:3,4,5-3,4,5 | Lateral bundles in V-VI with only 1 enlarged chaeta. | 3 | 0 | ? | ? | XII-XV | XII | 1 | absent | 7/8 |
| <i>C. quadrosetososa</i> Christensen & Dózsa-Farkas, 1999 | 3,4-3:4,5-3,4 | no | 3 | 0 | 0 | 3 | XIII | XII | 2 | present | 6/7 |
| <i>C. lapponica</i> Numminen, 1965 | 3-3-3-3-3 | no | 3 | 0 | 0 | 2 | X? | XII | 2 | present | 6/7 |
| <i>C. baekrokdamensis</i> (Dózsa-Farkas, Felföldi, Nagy & Hong, 2018) | 3-3:3-3 | no | 3 | 0 | 0 | 2 | XIX | XII | 2 | small | 6/7 |
| <i>C. paxi</i> (Moszyński, 1938) | 3-3:3-3 | no | 4 | ? | 1? | ? | ? | X | 1 | absent | 4/5 |
| <i>C. zicsii</i> Dózsa-Farkas, 1989 | 3-3:3-3 | no | 3 | 0 | 2 | 0 | XIV | XII | 2 | present | 6/7 |
| <i>C. pseudosphagnetorum</i> (Martinsson, Rota & Erséus, 2015b) | 3-3:3-3 | no | 3-4(-5) | 0 | 0 | 0 | X-XIV | VIII | 2 | present | 8/9-9/10 |
| <i>C. sphagnetorum</i> (Vejdovský, 1878) | 3-3:3-3 | no | (3-4)(-5) | 0(-1) | 0-2 | 0 | XI-XIII | IX | ? | present | 7/8-10/11 |
| <i>C. hibernica</i> Healy, 1975 | 2-2:2-2 | no | 3 | 2 | 1 | 2 | XII/XIII | XII | 1 | present | 6/7 |
| <i>C. bisetososa</i> Christensen & Dózsa-Farkas, 1999 | 2-2 : 2(3)-2 | no | 3 | 2 | 1 | 2 | XII | XII | 2 | absent | 6/7 |
| <i>C. ozensis</i> (Torii, 2015) | 3-3:3,3(2)-3(2) | no | 3 | 0 | 0 | 2 | XIV-XV | XII | 1 | absent | 7/8 |
| <i>C. floridae</i> Healy, 1996 | (2)3-(2)3:(2)3-(2)3 | no | 3 | 0 | 0 | 2 | XIII-XV | XII | 1 | no/fused with duct | 6/7 |
| <i>C. glandulosa</i> (Michaelsen, 1888) | 2,(3)-3:3-3 | no | 3-4 | 0 | 0 | 2-4 | XVI-XX | VIII-IX | 2 | present | 7/8-8/9 |
| <i>C. varisetosa</i> (Martinsson, Rota & Erséus, 2015a) | 2,3-(2),3:3-3 | no | 3-4 | 0 | 0 | 3-4 | XIII-XVII | VIII-IX | 2 | present | 8/9-11/12 |
| <i>C. valeriae</i> Dumnicka, 2010 | 2,3-3:3-3 | no | 5 | 2 | 2-3 | 0 | XXII | X | 2 | present | 10/11? |
| <i>C. chalapyskyi</i> (Martinsson, Rota & Erséus, 2015b) | 3-3:3-3 2 chaetae lateral in II | no | (4)5(-6) | 2-4 | 0-2 | 0 | XVII-XXIV | IX-XII | 2 | present | 9/10-11/12 |
| <i>C. alsoae</i> (Martinsson, Klinth & Erséus, 2018) | 3-3:3-3 2 chaetae lateral in II | no | 4-6 | 0-2 | 1-2 | 0 | XV-XVI | IX | ? | ? | 5-6-6-7 |
| <i>C. chlorophila</i> (Friend, 1913) | 2,(3)-3:3-3 | no | (3-4)(-5) | 0 | 0 | 0 | IX-XI | VIII-IX | 2 | present | 8/9-9/10 |
| <i>C. anomala</i> (Černovítov, 1928) | 2,3-2,3:3-3 | no | 5 | 0? | 2 | 0 | XII-XIII | X | 1 | present | ? |

ampulla, and it is possible that some of the species with undeveloped ampulla were described on not fully mature material.

Many species reproduce mainly asexually, by fragmentation, and mature specimens may be rare. In these species, the genitalia are often shifted forward 1-4 segments.

The most useful characters for identifying *Cognettia* species are 1) the chaetae, the presence/absence of enlarged chaetae in anterior (preclitellar) lateral bundles, and the number of chaetae per bundle; and 2) the pharyngeal glands, presence/absence of secondary glands, and ventral lobes, the number of pairs of glands, and whether some pairs are fused dorsally or not. Other characters that can be important are the position of the origin of the dorsal blood vessel, position of the anteriormost pair of nephridia, and characters in the spermatheca. As many species reproduce asexually, the key focuses on non-sexual characters.

3. Key to the species of *Cognettia*

1. 1-2 enlarged chaetae in lateral bundles of 2-3 segments within III-VII. 2
 - No enlarged chaetae. 3
2. 2 enlarged chaetae per bundle, spermatheca with ectal gland and ampulla divided into two chambers (see Fig. 1D). *C. cognettii* (Issel, 1905)

The enlarged chaetae are not mentioned as such in the original description, but the length range of chaetae given include them (see Schmelz & Collado 2010). The position of the enlarged chaetae are somewhat variable, they have been observed in III-V or IV-VI in material from the former Yugoslavia (Cernovitov 1945), in V-VII in material from Britain (Cernovitov 1945), in IV-VI or V-VII in material from Germany (Römbke 1989), and in V-VII in material from Scandinavia (pers. obs.). The species is distributed widely in Europe.

 - 1 enlarged chaeta per bundle, spermatheca without ectal gland, and ampulla not divided into two chambers. *C. hayachinensis* Nakamura, 2001

So far only found in Japan.
3. At least 3 chaetae in all bundles. 4
 - All or some bundles with two chaetae. 10
4. Some bundles with 4 chaetae.
 - *C. quadrosetosa* Christensen and Dózsa-Farkas, 1999

An Arctic species, recorded from the Siberian tundra and N Greenland.
 - 3 chaetae in all bundles. 5
5. With well-developed secondary pharyngeal glands (see Fig 1A). 6
 - Without secondary pharyngeal glands, but ventral lobes may be present (see Fig 1B). 9
6. Dorsal blood vessel arises in X, spermathecal duct without ectal swelling, but ectal gland well-developed (see Fig. 1D). *C. lapponica* Nurminen, 1965

An Arctic species, recorded widely from the N Palearctic region.

 - Dorsal blood vessel arises in XIV, spermathecal duct with or without ectal swelling. 7
7. Spermathecal duct without ectal swelling, ectal gland well developed. 3 pairs of pharyngeal glands, the two posteriormost with well-developed secondary glands, first pair of nephridia at 6/7, male pores in XII. *C. zicsii* Dózsa-Farkas, 1989

A South American species, known from the Ecuadorian Andes.

 - Spermathecal duct with ectal swelling, ectal gland missing or rudimentary. 8
8. Spermathecal duct with ectal swelling (see Fig. 1C), and a rudimentary ectal gland, spermatheca with ampulla divided into two chambers. Sperm funnel 2-3 times as long as wide. First nephridia at 6/7. *C. baekrokdamensis* (Dózsa-Farkas, Felföldi, Nagy & Hong, 2018)

An E. Asian species, found in S Korea and Yunnan, China.

 - Spermathecal duct with ectal swelling (see Fig. 1C), without ectal gland, spermatheca with ampulla not divided into two chambers. Sperm funnel 4-5 times as long as wide. First nephridia at 6/7. *C. floridae* Healy, 1996

Only known from Florida, USA, this species is described to have 3 chaetae per bundles, in all body regions, occasional only two, therefore this species found in two places in the key.
9. First pair of nephridia at 4/5, four pairs of pharyngeal glands, male pores in X, spermathecal ectal gland absent. *C. paxi* (Moszyński, 1938)

A doubtful species, the spermathecae indicate that it was possibly described from submature specimens. However, the position of the first pair of nephridia is unique for the genus, and if this is correct it is most likely a valid species. Described from C Europe.

 - First pair of nephridia at 7/8-10/11, 3-5 pairs of pharyngeal glands, 0-2 with ventral lobes, dorsal blood vessel arises in X-XIV, male pores shifted forward to VIII-IX. *C. sphagnetorum* (Vejdovský, 1878)/*C. pseudosphagnetorum* (Martinsson, Rota & Erséus, 2015b)

A cryptic species pair that can only be separated using molecular methods, both species found in Europe. Due to the recent split-up of the *C. sphagnetorum* complex it is in many cases impossible to know which species older records of '*C. sphagnetorum*' refer to.

- 10.2** chaetae per bundle in most or all bundles, both ventral and lateral. 11
 - 3 chaetae in a majority of the bundles, particularly postclitellarly. 12
- 11.** Spermathecal ampulla not divided into two chambers, ectal duct with ectal gland present. Three pairs of pharyngeal glands, the two posteriormost with well-developed secondary glands, and the two anteriormost fused dorsally.
 *C. hibernica* Healy, 1975
 Found in Ireland, Portugal and NW Spain, possibly an Atlantic species.
 - Spermathecal ampulla divided into two chambers, ectal gland absent. Three pairs of pharyngeal glands, the two posteriormost with well-developed secondary glands, and the two anteriormost fused dorsally.
 *C. bisetosa* Christensen and Dózsá-Farkas, 1999
 An Arctic species, recorded from the Siberian tundra.
- 12.** Well-developed secondary pharyngeal glands in 2-4 pairs. 13
 - Secondary glands absent, but ventral lobes may be present in 1-3 pairs. 16
- 13.** 3 chaetae in all lateral bundles, 2 chaetae in some ventral bundles. *C. ozensis* (Torii, 2015)
 So far only known from Japan.
 - 2 chaetae in some lateral bundles, 2 or 3 chaetae in ventral bundles. 15
- 14.** First nephridia at 6/7, 3 pairs of pharyngeal glands, the two posteriormost with well-developed secondary glands, spermatheca with ampulla not divided into two chambers, ectal gland absent, duct with glandular swelling (Fig 1C). *C. floridae* Healy, 1996
 Only known from Florida, USA, this species is described to have 3 chaetae per bundles, in all regions, occasional only two, therefore this species found in two places in the key.
 - First nephridia at 7/8-11/12, 3-4 pairs of pharyngeal glands, 2-4 with secondary glands, spermatheca with ampulla divided into two chambers, ectal gland present (Fig 1D). 15
- 15.** 2 chaetae in all anterior (preclitellar) lateral bundles, 3 in other bundles, dorsal blood vessel arises in XVI-XX. Found in fully aquatic habitats.
 *C. glandulosa* (Michaelsen, 1888)
 Molecularly confirmed records from N and C Europe, but the species likely has a wider distribution, but many older records may refer to *C. varisetosa*.
 - A mix of 2-3 chaetae in anterior (preclitellar) lateral bundles, sometimes 2 chaetae in all anterior lateral bundles and 3 in all other bundles, dorsal blood vessel arises in XIII-XVII. Found in semiaquatic and aquatic habitats.
 *C. varisetosa* (Martinsson, Rota & Erséus, 2015a)
 Holarctic, recorded from both Europe and Canada, many records of *C. glandulosa* may refer to this species. These two species overlap morphologically, and their identification may not always be possible using morphology alone.
- 16.** Dorsal blood vessel arises in XV or more posterior. Often with 2 chaetae only in lateral bundles in II, and 3 chaetae in remaining bundles. 17
 - Dorsal blood vessel arises in IX-XIII. With several lateral anterior (preclitellar) bundles with 2 chaetae. 19
- 17.** A mix of 2 and 3 chaetae in lateral anterior (preclitellar) bundles, 5 pairs of pharyngeal glands, 2 pairs fused dorsally, dorsal blood vessel arises in XXII, male pores in X. *C. valeriae* Dumnicka, 2010
 So far only known from the Italian Alps, described from streams.
 - 2 chaetae in lateral bundles in II, 3 chaetae in other bundles, 4-6 pairs of pharyngeal glands, 0-4 pairs fused dorsally, dorsal blood vessel arises in XV-XXIV, male pores in IX-XII. 18.
- 18.** 2-4 pairs of pharyngeal glands fused dorsally, dorsal blood vessel arises in XVII-XXIV, male pores in IX-XII.
 *C. chalupskyi* (Martinsson, Rota & Erséus, 2015b)
 Known from N and C Europe.
 - 0-2 pairs of pharyngeal glands fused dorsally, dorsal blood vessel arises in XV-XVI, male pores in IX.
 *C. asloae* Martinsson, Klinth & Erséus, 2018
 A Scandinavian species, found in Denmark, Norway, and Sweden, mainly aquatic.
Chamaedrilus alsoae is only known from a small number of specimens from Scandinavia, and it is possible that there will be even more morphological overlap with *C. chalupskyi* when more material is studied.
- 19.** 3-5 pairs of pharyngeal glands, ventral lobes absent, chaetal formula 2.(3)-3:3-3, male pores in IX-XI, spermathecal ampulla divided into two chambers.
 *C. chlorophila* (Friend, 1913)
 Widely distributed in Europe.
 - 5 pairs of pharyngeal glands, 2 pairs with ventral lobes, chaetal formula 2,3-2,3:3-3, male pores in X, spermathecal ampulla with a single chamber.
 *C. anomala* (Černovítov, 1928)
 A doubtful species, the spermathecae indicate that it was possibly described from submature specimens, and it is possible that it is a synonym to *C. chlorophila*. Described from the Carpathians.

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