What is *Cloeon dipterum* (Linnaeus, 1761)?

The Nomenclatural and Morphological Analysis of a Group of the European Species of *Cloeon* Leach (Ephemerida: Baetidae)

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Abstract

A comparative description of imagines, subimagines, and nymphs of *Cloeon dipterum* (L.) s.r., *C. cognatum* Stephens stat. nov., and *C. inscriptum* Bengtsson stat. nov. is given on the basis of reared material from southern Poland. The recognized and probable synonyms of these species are discussed on the basis of the data from European literature. Remarks about the material from other parts of Europe and about the type specimens of the three species are also given.

1. Introduction

Cloeon dipterum (L.) s.l. is one of the most common and most abundant species among the aquatic insects of Europe. Its nymphs are characterized by long, filamentous antennae and tails, three-segmental maxillary palp, last segment of labial palp hoof-shaped, and seven pairs of rounded gills of a patchy branched tracheation, the first six pairs having an additional large lamella.

Great numbers of such nymphs occur in concrete culture tanks in the garden of the Institute of Zoology of the Jagiellonian University in Kraków. From the middle of July to the middle of September, 1973, in summer 1974, and in May 1975 I was carrying out a laboratory rearing of maturing nymphs caught in these tanks, and obtained above 350 winged specimens (imagines and subimagines) of the two sexes with corresponding nymphal exuviae. According to the differences in the colour pattern and to the morphological differences I managed to divide the whole material to three separate populations which, I suppose, belong to three different though highly related species. One of these species, with cylindrical turbinate eyes of the imago male, is known in the literature as *Cloeon inscriptum* Bengtsson, the other two, whose adults males have turbinate eyes distinctly widened upwards but of different colours, are both, by various authors, determined as *Cloeon dipterum* (L.). Since these three species have nymphs which, according to even the most recent systematic works (Macan 1949, 1970, Grandi 1960, Landa 1969), should be classified to *C. dipterum,* one may suppose that many data reported so far about the Linnaeus species, especially with regard to nymphs, may as well relate to each one of these three species. Hence, it seems necessary to determine the Linnaeus species more precisely and to establish an available name for the other one, mistaken with it so far.

2. Nomenclatural appointments

Cloeon dipterum (L.) s.l. is among the mayfly taxons which are richest in junior synonyms. Eaton (1885) distinguished within this species the four varieties from different parts of Europe, regarding as typical the variety whose adult males have dull light reddish, or reddish clove-brown turbinate eyes and a dark dorsal part of abdomen with rich maculation.

Another concept of the Linnaeus species was proposed by Bengtsson (1914). He limited it to the population in which adult males have yellow turbinate eyes and abdominal segments 2—6 whitish, transparent, and only slightly spotted. Bengtsson's interpretation is supported by Ulmer (1929), Schoenemund (1930), Mikulski (1936), and Tshernova (1964). Nevertheless, some authors, e.g. Grandi (1960, 1960a) still adhere to the concept of Eaton (1885) and some others, e.g. Landa (1969) regard the three species as only populations of the polymorphic *C. dipterum* (L.). It is very difficult to agree with the last concept. The nymphs

collected by me, although almost identical morphologically and very variable in their pigmentation, may be easily separated into three groups according to certain features of the body pattern. Each of them reared separately gives adults distinctly different with regard to the colour pattern, and certain morphological features of the male genitalia. In the present work I accept Bengtsson's opinion. Since the original material of the Linnaeus species is not preserved and the original description given by Linnaeus is not sufficient for identification, out of the two similar common concepts of the Linnaeus species, that of Bengtsson seems more probable, being also based on Swedish material. I regard *C. inscriptum* Bengtsson as a true species.

Still, there remains the determination of a valid name for the third species reared, i.e. for *C. dipterum* sensu Eaton 1885 pro parte, the variety 1. According to the data of Eaton (1885) one may indirectly conclude that out of the varieties distinguished by him, only this one was found in Great Britain. It is from Great Britain that the oldest of junior synonyms of *C. dipterum* (L.), which were not the object of Bengtsson's revision (1914), come from. The oldest of them whose type material, as far as I know, was not preserved, was *C. pallidum* Leach, and according to the Law of Priority the name given by Leach (1815) should be used for this species. Still, judging from the name, (Leach did not give a proper description of his species), he must have dealt with a female only, possibly even in the subimago stage. The females of all three species have fairly similar light colour and considering the case with which these species migrate, the presence of at least one other of them in Great Britain is quite possible. Therefore the identity of the species of Leach with the variety 1 of *C. dipterum* sensu Eaton remains uncertain. Because of similar reasons the identification of three species of Curtis (1834): *C. dimidiatum, C. marmoratum,* and *C. obscurum* is also uncertain. They were described from England and afterwards treated as the junior synonyms of *C. dipterum* (L.) (Eaton 1871, 1885, Kimmins 1957, Grandi 1960). The original descriptions do not allow these species to be recognized and the fate of type-specimens is unknown. The first of these junior synonyms of *C. dipterum* (L.) whose original material, still in a good state of preservation, was studied by Eaton himself (1885) and whose holotype (male imago, dry and without abdomen) is preserved in the British Museum (N.H.), is *C. cognatum* Stephens reported by Stephens (1835) among others from the region of London. According to a personal communication from Dr P. H. Ward dealing with this holotype: "... the dorsal surface of the turbinate eye was approximate to twice the base. The colour now is brownish, with the margins fuscous-yellow. There is a considerable amount of red pigment revealed where the eyes are broken, which leads me to think that they were probably red in life." Thus, for the determination of the third species of those reared by me I have decided to accept the name given to it by Stephens.

In accordance with the opinion of Bengtsson (1913) I regard *Cloeon rufulum* (O. F. Müller) as a junior synonym of *C. dipterum* (L.). The doubts expressed by Kimmins (1957) with regard to their identity result from the fact that this author's idea of a Linnaeus species is different from that presented here.

Since as far as I know the original material of the Linnaeus species is not preserved, the necessity occurs to designate a neotype from the Swedish population.

The lectotype of *C. inscriptum* Bengtsson, imago male, was designated by Per Brinck and I. Müller-Liebenau in 1961 (unpubl.) from the collection of Bengtsson. It comes from the region of Lund, was caught on 6 June 1903, and is kept (in alcohol) in the Ent. Mus., Zool. Inst. University of Lund. This specimen, which I had the opportunity of seeing, does not differ from the males of this species from the region of Kraków.

Synonymy of the three species

The established and probable synonymy presented below of the three species is only concerned with more important publications, above all those of a taxonomic character.

Cloeon dipterum (L., 1761)
=*annulatum* (O. F. Müller, 1776)
=*rufulum* (O. F. Müller, 1776) syn. nov.
?=*szegedi* Jacob, 1969
=*dipterum:* Eaton 1885 pro parte, var. 3 and var. 4?); Bengtsson 1914; Ulmer 1929; Schoenemund 1930; Mikulski 1936; Bogoescu 1959; Ujhelyi 1959; Tshernova 1964; Landa 1969 p.p.

Cloeon cognatum Stephens, 1835 stat. nov.
?=*pallidum* Leach, 1815
?=*dimidiatum* Curtis, 1834
?=*obscurum* Curtis, 1834
?=*marmoratum* Curtis, 1834
=*consobrinum* Stephens, 1835 syn. nov.
=*virgo* Stephens, 1835 syn. nov.
=*affinis* (Rambur, 1842) syn. nov.
=*apicalis* (Costa, 1882) syn. nov.

Size of summer generations (in mm):

Stage	Imago ♂		Imago ♀			Nymph
Length	body and wings	cerci	body	wings	cerci	body
Cloeon dipterum	6.5—7.5	12—14	7.0—8.5	7—8	10—11	6.0—8.0
Cloeon cognatum	6.5—7.5	14—15	7.0—9.0	7—9	13—14	7.0—9.0
Cloeon inscriptum	6.0—7.0	12—13	7.0—8.0	7—9	10—12	5.5—8.0

=*dipterum*: Pictet 1843—45; Eaton 1871 p.p., 1885 p.p. var. 1; Macan 1949; 1970; Kimmins 1954; Grandi 1960, 1960a; Landa 1969 p.p.

Cloeon inscriptum Bengtsson, 1914 stat. nov.
=*dipterum*: Eaton 1871 p.p. var.; 1885 p.p. var. 2?; Landa 1969 p.p.
=*inscriptum:* Ulmer 1929; Schoenemund 1930; Mikulski 1936; Tshernova 1964.

3. Discussion on the taxonomic differences between the species according to the reared material from southern Poland

The comparative description given below takes basically into consideration these systematic features only, which differentiate the three species. It concerns the material living or kept in alcohol for no longer than 2—3 days. Keeping specimens in alcohol brings about changes in their pigmentation after a few weeks and the differences in this respect become hardly visible especially in females.

Material: Kraków, culture tanks in the garden of the Zool. Inst., Jagiellonian University, alt. 200 m, 20.VI—15.X.1973, 20.VIII—20.IX.1974, 15.V—30.V. 1975. *C. dipterum* (L.): 28 ♂♂, 32 ♀♀ im., 17 ♂♂♀♀ subim., numerous nymphs and nymphal exuviae. — *C. cognatum* Stephens: 90 ♂♂, 82 ♀♀ im., 51 ♂♂♀♀ subim., numerous nymphs and nymphal exuviae — *C. inscriptum* Bengtsson: 47 ♂♂, 27 ♀♀ im., 15 ♂♂♀♀ subim., numerous nymphs and nymphal exuviae (reared). [Measurements — vide table above.]

Adult males

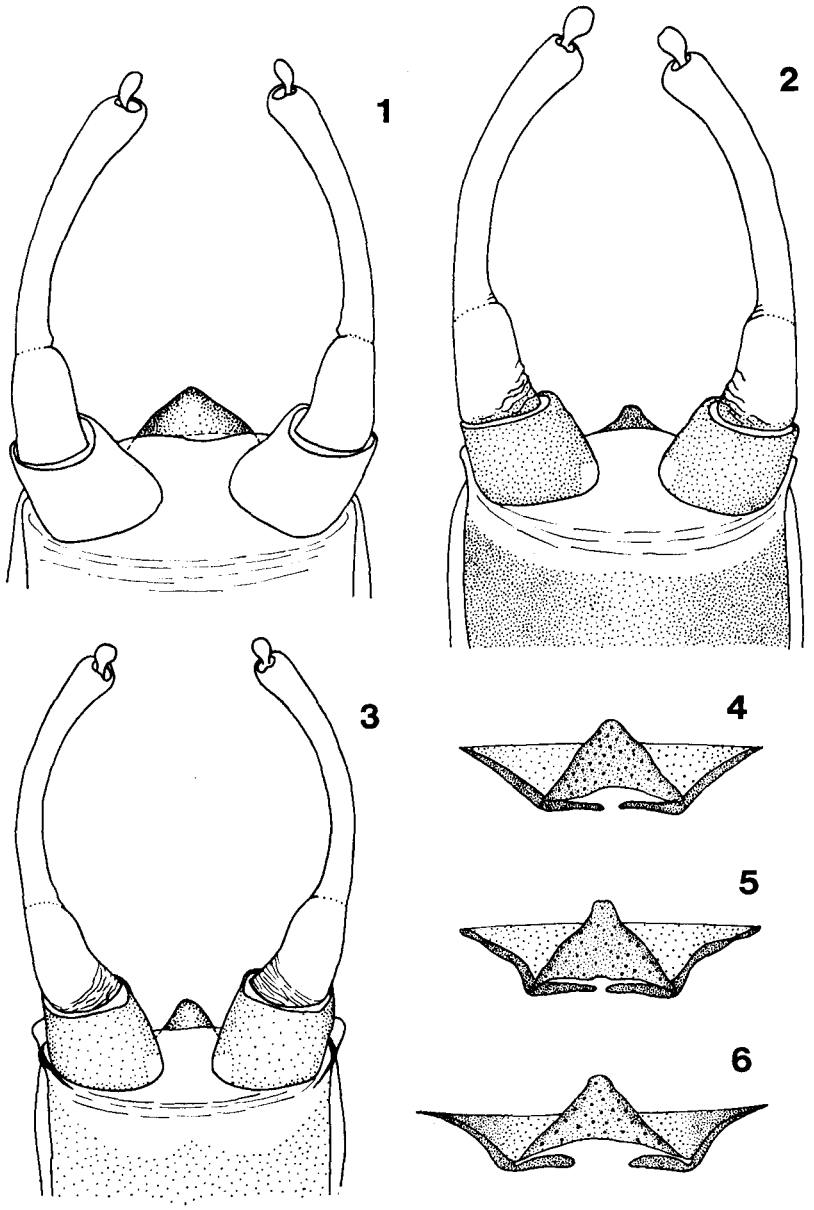
Body colouring of *C. dipterum* s.r. is fairly light. Thorax brown or light brown, abdominal segments 2—6 whitish, transparent, with slight elongated rusty-orange spots on the sides of tergites, and sometimes also of sternites. Further tergites uniformly rusty-orange, the sternites whitish. Coxa of medium and hind legs with a single rusty-orange spot on the inner side. A similar spot is also visible at the end of femurs. The body pigmentation of *C. inscriptum* and particularly that of *C. cognatum* is distinctly darker: thorax dark brown, sometimes almost black, abdomen wine-red, the spot on coxa and femur bright wine-red. In *C. inscriptum* the shape and the distribution of spots on abdominal segments 2—6 are similar to the distribution of spots in *C. dipterum*; these segments are free of spots in their central parts and slightly transparent, while in the male of *C. cognatum* the surface of all abdominal segments shows abundant maculation, consisting of large semi-circular side spots and a double or single central spot on each segment (cf. Grandi 1960: 189, fig. 62).

Turbinate eyes of *C. dipterum* are medium high, distinctly widened upwards, and uniformly yellow-lemon. In *C. cognatum* they are of similar form but their upper surface is of liver-red colour with a light marginal rim. Upper part of side wall is orange-yellow, lower part slightly darker. In *C. inscriptum* the eyes are high, cylindrical. Seen from above they have an almost round shape. Basal part of side wall is red or orange red and the nearer to the upper edge of the eye this colour gradually changes into yellow.

The *segments of legs* are of similar proportions of length in the three species: the tarsus of the medium and hind leg has the second segment twice or slightly more than twice shorter than the first one.

Cerci of all three species are light with distinct violet-black rings. Usually every second ring is markedly wider.

Forceps of all three species are slender and their basal segment (figs 1—3) is distinctly shorter than the second one, this being hardly separated from the third. In *C. dipterum* the basal segment is whitish, in other species more or less distinctly dark brown or wine-red. In *C. dipterum* at the base of the third segment of forceps a small spur usually occurs (fig. 1), being absent in the other two species. The last segment of the forceps of *C. dipterum* is slender, while in *C. cognatum* it is



Figs 1—6. Genitalia in imago male. — 1 and 5. *Cloeon dipterum* (Linn.). — 2 and 6. *C. cognatum* Steph. — 3—4. *C. inscriptum* Bengtsson. Figs 1—3. Genitalia from ventral side. — Figs 4—6. Penis from ventral side. Material from southern Poland.

rounded and relatively large (fig. 2). Forceps of *C. inscriptum* are more slender than with the other species and the last segment is rounded and small (fig. 3).

Penis is similar in all three species: it is a cone bent backwards, more strongly sclerotized on the ventral side. It is fastened to the body with two arms, may be stuck backwards and moved up and down. Depending on its position it has various aspects when viewed from the ventral side (figs 4—6).

Adult females

Adult females of the three species are very similar morphologically, but differ from each

other fairly distinctly in the colour and distribution of spots on the body.

The basic body colouring of C. dipterum is orange yellow, "warm". Orange-rust spots of abdomen do not stand out brightly against the background of the colour, however they are rather dark. Females of the other two species have the basic pigmentation pale white or white-cream, "cold", the wine-red or rust-red maculation of abdomen standing out brightly against it. In *C. cognatum* central spots also occur on abdominal tergites 2—7 similar to male, while they are absent (on certain tergites at least) in female *C. dipterum* and *C. inscriptum*. In the *C. inscriptum* female the abdomen in profile has decisively lighter spots on the dorsal side as compared with the spots on the ventral side; the pigment intensity of the two sides of abdomen being similar with the female of *C. dipterum*.

The *compound eyes* of *C. dipterum* and *C. inscriptum* females are ornated with two narrow longitudinal bands, while in the female of *C. cognatum* a third band also appears, lighter and broader, lying just at the upper margin of the eye. In all species the general colour of compound eyes is light grey, becoming almost black in some specimens after several days of adult life.

The wings having the costal and subcostal fields distinctly brown coloured in all species and the transversal veins occurring here are broadly bordered with white. Besides long transversal veins the female of *C. dipterum* also has numerous rudimental crossveins in the costal field, their number amounting to at least 10 in the whole length of the field. Similarly numerous transversal veins are found in the *C. inscriptum* female where both fields are dark brown, while in the costal field of *C. cognatum* a few rudimentary crossveins, usually below 5, more rarely below 10, are observed, the colour of both fields being light brown of slightly greenish hue.

Cerci coloured similarly to these of males.

Subimagines

In this stage the species compared differ from each other in the features of the colour and maculation, similarly as it was discussed for adult stages. Males above all differ in the colour and shape of the turbinate eyes and in the distribution and colour of spots on the abdomen, females in the number of bands on the compound eyes and in the pigmentation of abdomen. The wings of all species are uniformly grey.

Eggs

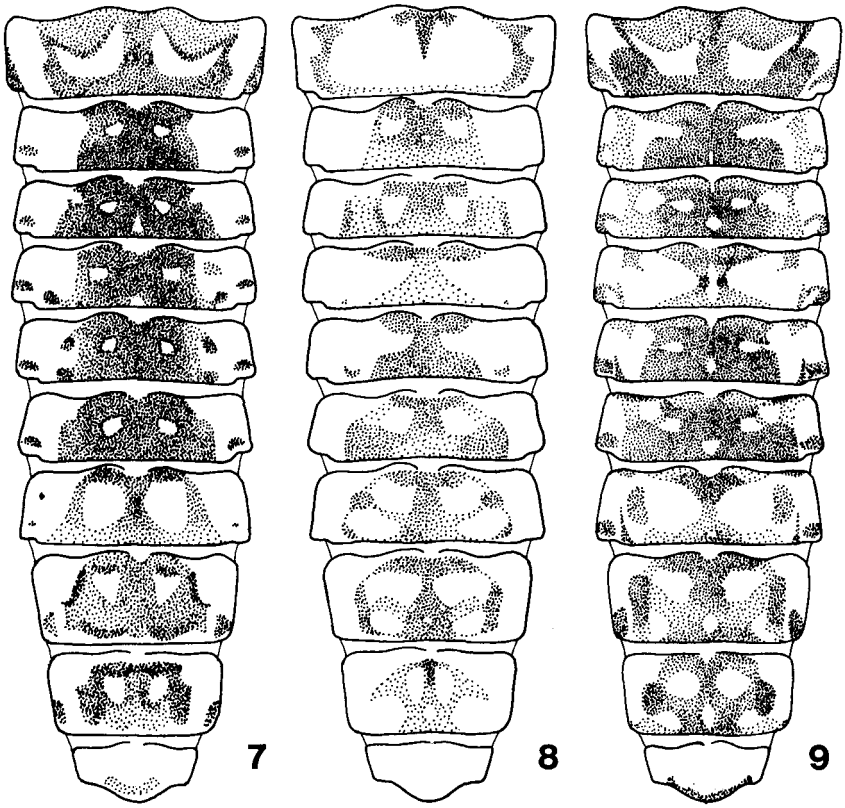
The eggs of the three species are similar and agree with the description of the egg of *C. dipterum* (L.) reported by Degrange (1960). Chorion is very thin, modulated by the internal balls of the yolk. The surface of chorion is irregularly fine-grained.

Nymphs

The nymphs of all species showed a very variable body pattern. Particularly variable is the distribution of spots on the abdominal tergites. Nevertheless, some different repetitive elements of the pattern may be observed in particular species, this permitting their proper identification already in the stage of young nymph using a stereomicroscope.

At the distal end of femur of the medium and hind legs the nymphs of *C. dipterum* have a distinct dark spot, absent in the other two species. The joints of segments in three tails, in the part between the base of tail and the medium band, are dark brown or black in *C. dipterum* and *C. inscriptum*, standing out distinctly against the light background of tails and forming fairly broad rings. In *C. cognatum* the joints of segments are of a light rust colour and form narrow rings, rather indistinctly marked on the light background of tails. The dorsal side of the body of *C. cognatum* is slightly pigmented. On the abdomen light spots prevail, the sides of abdominal tergites 2—9 are wholly devoid of dark spots, indistinct darkenings being only visible here sometimes (fig. 8); the two light spots lying centrally on particular tergites are usually large in this species. The dorsal surface of abdomen of *C. dipterum* nymphs is mostly dark and two yellow central spots are rather small and directed backwards obliquely (fig. 7). The sides of abdominal tergites 2—9 have a dark little spot near the end of the hind angle. The nymphs of *C. inscriptum* have the most variable maculation on the dorsal side of the body. Generally, it is in accordance with the maculation of *C. dipterum*, however, on the first few tergites of the abdomen the two central light spots lie transversally in relation to the body axis (fig. 9), while the dark spot on the sides of tergite 9 is weakly visible or does not occur.

There are few morphological differences between the nymphs of the three species. In *C. cognatum* the terminal segments of abdomen are slightly broader in relation to those in other species. The labium of *C. cognatum* has slightly more numerous hairs on its outer surface. The claws of all three species have two rows of

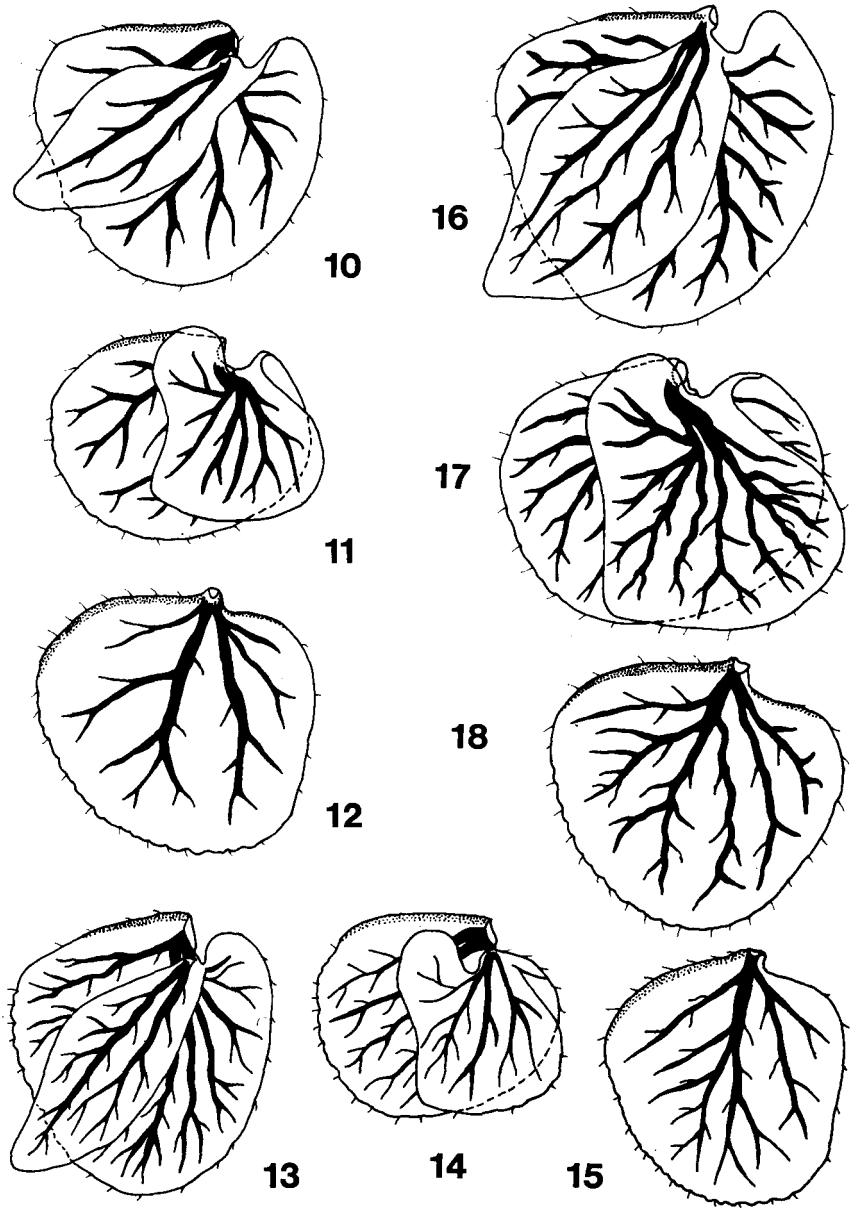


Figs 7—9. Example of abdominal pattern of the nymph. — 7. *Cloeon dipterum* (Linn.). — — 8. *C. cognatum* Steph. — 9. *C. inscriptum* Bengtsson. Material from southern Poland.

relatively large denticles on their inner side. In *C. cognatum* both the claws and the denticles are more slender than in two other species. In the foreleg of this species the rows of denticles reach almost half the length of the claw, in *C. dipterum* they slightly exceed half the length of the claw while in *C. inscriptum* they take up two thirds of the length of the claw. Gills of the three species are of the same type; they are fairly variable in the shape and degree of branching of tracheae. The difference in the shape and size of the upper lamella of the first gill of *C. inscriptum* in relation to *C. dipterum,* stressed by Bengtsson (1914, 1936) and by Mikulski (1936), was not observed in the material investigated. The size of this lamella is variable, depending on the age of nymph, on the sex and also, it seems, on the environmental conditions (figs 10, 13, 16). Generally, mature nymphs of *C. dipterum* and *C. cognatum* have the sixth gill equal or slightly smaller than the seventh, while with the nymphs of *C. inscriptum* it is slightly greater (figs 11, 12, 14, 15, 17, 18). The form of mouthparts, size of antennae and tails, the form and pilosity of legs, and the microsculpture of the body surface are similar for the three species and agree with the description by Macan (1949).

4. Remarks on the material from other parts of Europe

From England I obtained about 30 young nymphs, of body length 3—5 mm, collected in Hodson's Tarn near Windermere on 22 October 1973, 7 nymphs from the Lost Tarn from 12 June 1974, and the reared material, 3 ♂, 1 ♀, imago+3 nymphal exuviae, from Hodson's Tarn from June 1974 (leg. T. T. Macan). In my opinion this whole material belongs to *C. cognatum* Stephens, however, it shows certain differences in relation to the Polish populations of this species; the nymphs show rather darker pigmentation and the design on the abdomen is more indistinct. The rings of tails are narrower but their colour is dark brown. Male imagines have



Figs 10—18. Gills in female nymph. — 10—12. *Cloeon dipterum* (Linn.). — 13—15. *C. cognatum* Steph. — 16—18. *C. inscriptum* Bengtsson. Figs 10, 13, and 16. First gill. — Figs 11, 14, and 17. Sixth gill. — Figs 12, 15, and 18. Seventh gill. Material from southern Poland.

fewer dark spots, distributed laterally on several of the first tergites. Forceps are similar but penis is less pointed at the end.

From Sweden, Scania (Krankesjön—Stensoffa) I obtained 25 nymphs of 3—4 mm size, collected on 18 September 1973 (leg. Per Brinck). The presence of a dark spot on femurs and the general pigmentation of abdomen suggest that a great majority of these nymphs belong to *C. dipterum*, some other most probably belonging to *C. inscriptum*. Also these nymphs are generally darker than the nymphs of the corresponding species from the region of Kraków.

The body maculation of several nymphs, of different sizes, of *C. dipterum* collected by me in one of the strongly eutrophicated ponds in the

environs of Slnćev Brjag in Bulgaria in June 1973, is brighter than that of the population from the region of Kraków; a greater part of abdomen being covered with light yellow spots.

5. General remarks

It seems that apart from local variability, all three species show fairly distinct geographical variability in the general pigmentation and distribution of spots. An analysis of this variability, and of the possible morphological changeability, should be the subject of further studies on a large material from various regions. Further investigations also seem necessary for the determination of limits of their maximum ranges. No doubt, in central and eastern Europe the three species occur sympatrically. *C. dipterum* and *C. inscriptum,* at the least, occur on the Scandinavian Peninsula, while *C. cognatum* is known to the British Isles. This last species is also found in southern Europe. The factors facilitating the dispersion of these species are their ovoviviparity, the viability of the female imago, and the relatively great independence of nymphs from environmental factors, this allowing the co-settlement of even temporary water bodies by the three species. The genetic isolation is chiefly ensured by the differences in the emergence pattern in the same water bodies.

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