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THE DISTRIBUTION AND ECOLOGY OF GROUND WATER AND RHEOPHILOUS FRESHWATER TRICLADS (PLATYHELMINTHES, TURBELLARIA) IN THE NETHERLANDS

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Abstract

This paper on the Dutch triclads contains information on the distribution and ecology of ground water and rheophilous species, *Phagocata vitta* (Dugès), *Dendrocoelum* spec., *Crenobia alpina* (Dana), *Dugesia gonocephala* (Dugès) and *Polycelis felina* (Dalyell). Localities and maps are given and the habitats of each species are described. Data are given on the water temperatures and pH measured at the localities of the rheophilous species and on the co-existence of these species with each other and with limnadophilous species.

C. alpina was often found alone or with *D. gonocephala*, occasionally with *P. felina*, and only very rarely with *Dendrocoelum lacteum* (O.F. Müller). *D. gonocephala* mostly occurred alone, at a few localities it was accompanied by *C. alpina* and *P. felina*, and sometimes by *D. lacteum*. *Polycelis nigra* (O.F. Müller) and *Polycelis tenuis* Ijima. *P. felina* was found mostly alone, further together with *Dugesia gonocephala*, and relatively often with limnadophilous species. Surprisingly, *P. felina* and *C. alpina* occurred together the least number of times. The reasons for this distribution are discussed. Water temperature, competition and the hydrological situation together seem to determine the distribution; the water chemistry seems to be of minor importance in the area studied.

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Introduction

The last survey of the Dutch triclads was given by van der Velde (1973). Observations have been made over the whole country and the present paper is a part of a new survey of Dutch triclads, which is now being prepared. At present 16 species of Tricladida are known from the Netherlands, viz. two species of Terricola, 13 species of Paludicola and one species of Maricola. Of the Paludicola the ground water and rheophilous species belong to the rarer triclads, because their habitat is restricted to the margins of the higher parts of the country. These parts are situated in the centre, the eastern and the south-eastern parts of the Netherlands (Fig. 1).

The rheophilous triclad species first recorded from the Netherlands was *Polycelis felina* (Dalyell, 1814) (Weber 1908). Romijn (1920) mentioned *Dugesia gonocephala* (Dugès, 1830) for the first time, while Voûte (1928) recorded *Crenobia alpina* (Dana, 1766). The historical sequence of discoveries is also a reflection of the sequence of rarity of these species in the Netherlands. *Polycelis felina* is relatively the most common species as it is known from 24 UTM squares of 10 x 10 km, while *Dugesia gonocephala* is known from 15 UTM squares, and *Crenobia alpina* from 9 squares.

Ground water species have been recorded much later than the rheophilous species, because of the difficulty of sampling in such habitats. A blind *Dendrocoelum* spec. was recorded by Stock (1962) and Mur-Atzema (1962), while *Phagocata vitta* (Dugès, 1830) was discovered by Tax & Neve (1975).

The localities of the rheophilous species in the province of Limburg have been summarized in Cuppen & van der Velde (1981), so that here only localities of those species outside Limburg are mentioned. In the case of the ground water species all localities are mentioned.

As no collections of triclad flatworms are available, only records from literature, personal communications of various hydrobiologists and own observations have been used. The source of data on the localities is indicated by a number in brackets which refers to the list of references.

Remarks on the species

Ground water species

Dendrocoelum spec. (Fig. 2, Table 3)

Localities: Obbicht, spring Kingbeek, 1962 (8); Geulhem, pump Kloostergroeve, 1962 (15).

In both localities immature specimens of a blind *Dendrocoelum* spec. were found. Stock (1962) mentioned specimens under the name *D. boettgeri* An der Lan, 1955 (identification An der Lan). According to Gourbault 1972) the diagnosis, as given by An der Lan (1955) is insufficient. In Europe many ground water species of *Dendrocoelum* are known (Gourbault 1972, Dahm & Gourbault 1978). The identity of the Dutch species requires elucidation.

Phagocata vitta (Dugès, 1830) (Fig. 3, Table 3)

Localities: Tienray (9, 16); Bredeweg (9, 16); Winterswijk, Woold (Mister Mark Waterlossing, Veerink Waterlossing and Siepersbeek) (2); Teuge, trench along Wezeveldseweg (4); Twello, tractor track in *Alnetum*, west of the Quabbenburgerweg (4).

Phagocata vitta has been found by Tax & Neve (1975) in completely or nearly completely closed ground water wells, which were used in the past for the supply of drinking water. The pH of the water of these localities ranged from 6.0 to 6.8 (Table 3), the water temperatures ranged from 6.5 to 9.0 ^{o}C. Near Winterswijk the species has been found in April and May in some temporary brooklets which emerge each year (Cuppen & Dirkse 1978). The species was most numerous in holes which were deeply cut out in the embankment of the brook behind small waterfalls and culverts. After the emergence of the brook bottom percolation still took place during a short period from the embankment. With the lowering of the ground water-level in June *P. vitta* disappeared. Probably the species then withdraws to the ground water. *P. vitta* was accompanied by the following triclads: *Dugesia lugubris* (O. Schmidt, 1860) (two localities), *Polycelis tenuis* Ijima, 1884 (one locality) and *Dendrocoelum lacteum* (O.F. Müller, 1773) (one locality).

P. vitta further was collected near Teuge and Twello in March in trenches which emerge yearly (Cuppen 1979). A possible explanation for the temporary above ground appearance of *Phagocata* is percolation from pleistocene sandy grounds (Teuge). At Teuge *P. vitta* was found together with *Dugesia lugubris*. In all localities *P. vitta* was represented by asexual specimens.

Rheophilous species

Crenobia alpina (Dana, 1766) (Fig. 4)

Localities outside Limburg: Springendalse beek near Ootmarsum (21, 22); Dunobeek near Ooster-

Table 1

The co-existence of rheophilous triclads with each other and with limnadophilous species in the Netherlands (data summarized from the literature)

	Number of localities	*Crenobia alpina*	*Polycelis felina*	*Dugesia gonocephala*	*Dendrocoelum lacteum*	*Polycelis nigra*	*Polycelis tenuis*	
Crenobia alpina	64	53.1	9.4	40.6	1.6	-.-	-.-	%
Polycelis felina	67	8.9	47.7	26.9	17.0	10.4	20.8	%
Dugesia gonocephala	236	11.0	7.6	77.1	4.6	3.4	2.9	%

beek (1, 10, 13, 17, 18, 19), Ubbergen, Hartenbeek, Pensionaat, Bronhuize, Beek, Kastanjedal, 'de Elzen', Vossenberg, Filosofendal T., all situated east of Nijmegen (10, 19).

Nearly all records of *C. alpina* were from springs and upper courses of hill brooks.

C. alpina is absent from the other hill brooks as suitable conditions there are temporary and the means of dispersal of the species are restricted.

The majority of the samples of *C. alpina* came from what we called 'point springs', in which the water is ejected strongly from a base of or along a more or less vertical face and then immediately runs away as a spring brook. The species was also found in unshaded helocrenes, shaded helocrenes, rheocrenes, wells and a limnocrene. In the upper courses of the hill brooks *C. alpina* was more often found in shaded than in unshaded areas.

Table 2

Water temperatures measured on localities of the rheophilous triclad species in the Netherlands (data summarized from the literature).

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	°C
C. alpina (n = 35)	-	-	-	-	2.9	-	2.9	17.1	37.1	25.7	2.9	2.9	8.6	-	-	-	-	%
P. felina (n = 42)	-	-	-	-	2.4	-	2.4	16.6	28.6	21.4	16.6	4.8	2.4	4.8	-	-	-	%
D. gonocephala (n = 130)	0.8	3.8	2.3	3.8	2.3	3.1	5.4	3.1	23.1	15.4	12.3	5.4	9.2	5.4	3.1	-	1.5	%

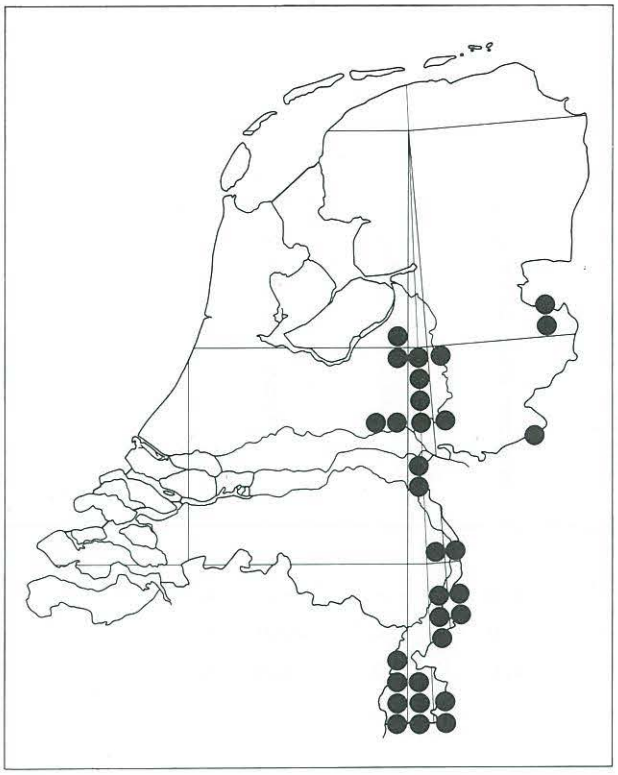


Fig. 1. Distribution of rheophilous and ground water species of triclads

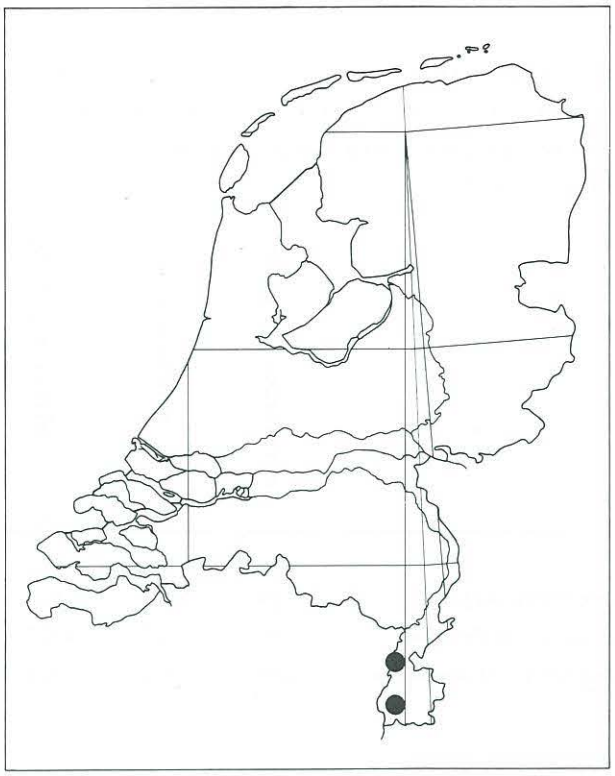


Fig. 2. *Dendrocoelum* spec.

Fig. 3. *Phagocata vitta* (left figure from Ball & Reynoldson 1981)

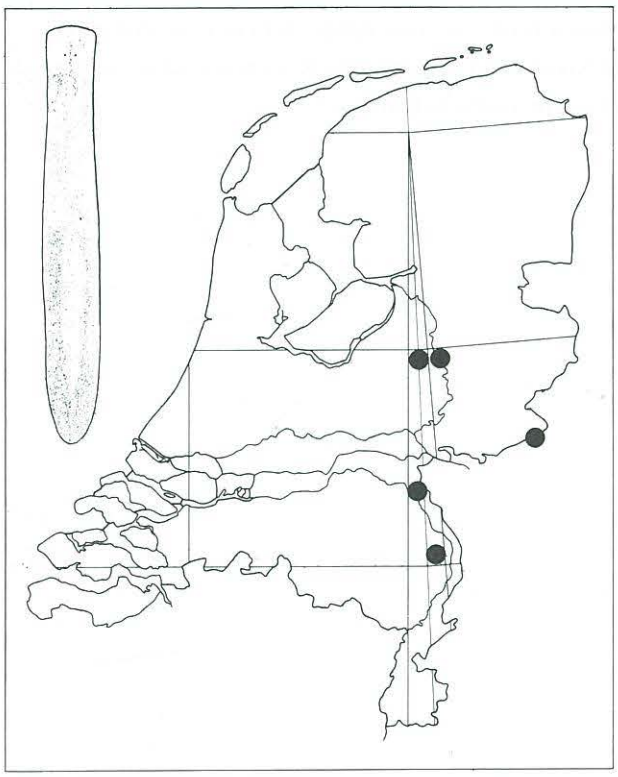
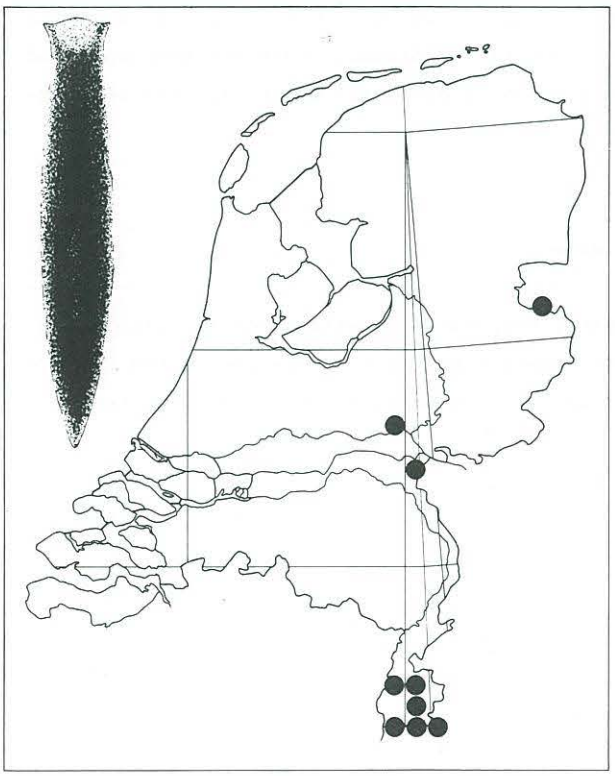


Fig. 4. *Crenobia alpina*



According to Oomen & Geelen (1966), *C. alpina* is confined to springs where water comes from larger depths. Such localities are present in the moraine hills, which were cut off transversely by a river and in the chalkhill area of South-Limburg where the hydrological situation is comparable.

As the distribution of *C. alpina* in the central area and the east of the Netherlands coincides with the occurrence of glacial sandy moraine hills, this species was considered belonging to the so-called relics of the glacial period. According to Voûte (1929) there is, however, no proof for a relic distribution in the Netherlands, as the distribution during the glacial period had to be the same as now. Certainly the glacial period is partly responsible for the formation of the suitable habitat for this species, which can be found over the whole of Europe in places where there are hills or mountains and where ground water emerges.

Dugesia gonocephala (Dugès, 1830)

Localities outside Limburg: Mosbeek, Springendal near Ootmarsum (9), Rossumerbeek near Duisterevoortsebrug (21, 22), brook in the property of Middachten (de Steeg) (pers. comm. E. Claessens).

D. gonocephala is very common in South-Limburg in springs, hill brooklets and larger hill brooks, such as the Mechelderbeek and Terzieterbeek and in brooks of the 'Geul-type', provided that they are not very heavily polluted. In spring environments the species is most often found at places with a fairly strong flow, such as the run out of helocrenes and 'point springs'.

In northern Limburg the species was found at places in a number of terraces east of the river Meuse, where a brook had ground out a deep bed, so that ground water, originating from greater depth, runs out permanently.

Outside the province of Limburg *D. gonocephala* is very rare, and only known from three localities where fast running streams come from moraine hills.

According to Redeke (1948), Weber (1908) should have found *D. gonocephala* in the Eerbeek in Gelderland, but this is not correct, as Weber (1908) mentioned, that he had searched for this species and found only *P. felina*.

Polycelis felina (Dalyell, 1814)

Localities outside Limburg: eastern ridge of the Veluwe: Epe, spreng Tongerensche Beek (23), Vaassen, sprengen Geelmolensche beek (11), Vaassen, sprengen Nijmolensche beek (5), Apeldoorn (6), Orderbeek (14), Apeldoorn, Zwaanspreng and Kayersbeek (12), Ugchelen, Koppelsprengen (Cuppen 1981, unpubl.), Beekbergen, spring area Beekbergsche Beek (3), Lieren, Beekbergsche Beek behind watermill of Goudkuil (Cuppen 1980, unpubl.), Loenen, mouth Veldhuizer spreng (Cuppen 1979, unpubl.). Southern ridge of the Veluwe: Renkumse beek (17), Oosterbeek (6), Dunobeek (19, 17, 10, 1), Voorbeek (6), Eerbeek (6), upper course Eerbeek (20), Seelbeek (1, 10, 17), Hoge Oorsprong (1, 10, 17), Hemelse berg (10), Zweiersdal beek (17), Mariendaal (10, 17), Zijpendaal (17), Rozendaalse beek (10, 17), Beekhuizen (6), Beekhuizense beek (17), Middachten (10, 17), Kleine Warnsborn (10, 17), beek of Wolfshezen (19), Velp-Arnhem springs (19). Area east of Nijmegen: Kastanjedal near Beek near Nijmegen (19), Pensionaat Ubbergen (10).

P. felina is restricted to hill brooklets and springs. In contrast to *C. alpina* and *D. gonocephala* this species was more often found in helocrenes than in 'point springs'. In southern Limburg the localities mainly coincide with the occurrence of sands of Aachen and Hervian sands. In northern Limburg the species was found in springs, spring brooks and brooks along the eastern and western ridge of the Meuse valley.

Outside the province of Limburg the species is fairly commonly found in springs and brooks which come from the glacial moraine hills situated east of Nijmegen and at the eastern and southern ridge of the Veluwe.

Leentvaar & Schimmel (1955) recorded the species from the province of Drenthe and den Hartog (1962) from the Gelderse Achterhoek near Winterswijk. The last two localities mentioned need confirmation. The Zeegse loopje, where *P. felina* should occur, has been investigated several times by Mr. A.S. Tulp (Tulp, in litt.), who

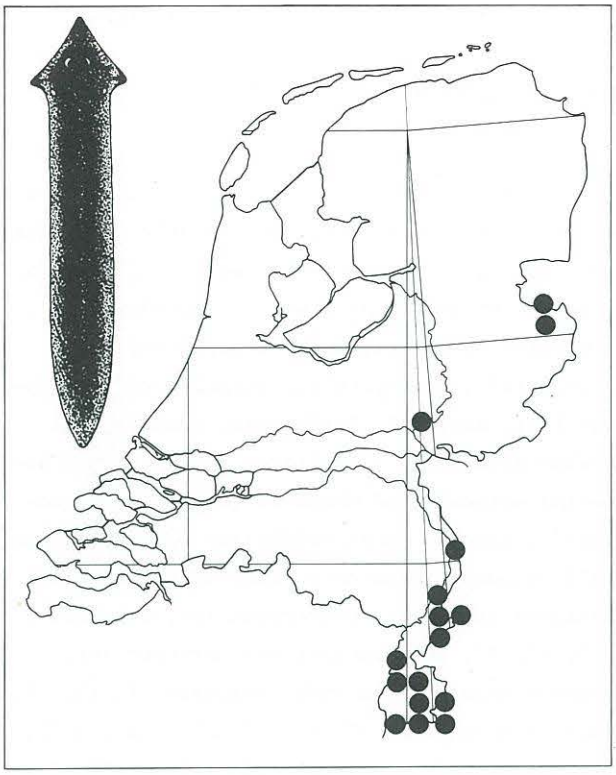


Fig. 5. *Dugesia gonocephala*

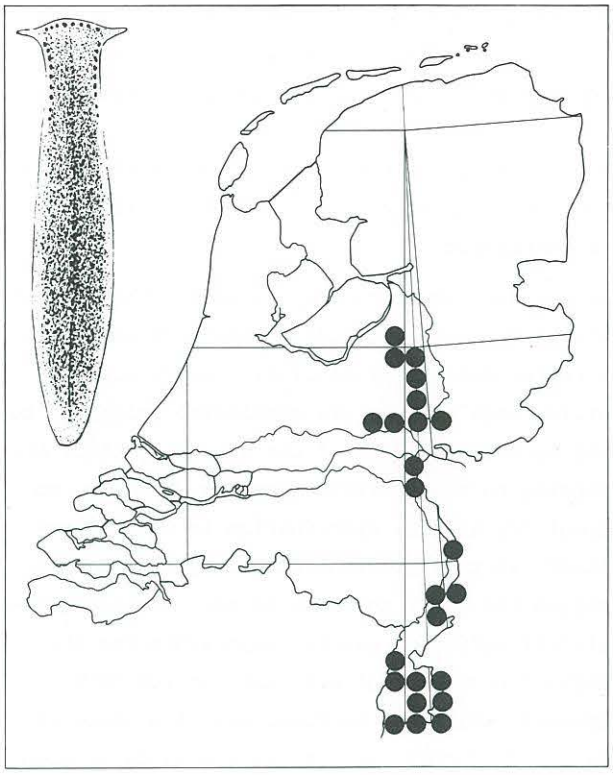


Fig. 6. *Polycelis felina*

Table 3

The pH of the water measured on localities of rheophilous and ground water species of triclads in the Netherlands (data summarized from the literature)

	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8
C. alpina (n = 16)	-	-	-	-	-	-	-	-	2	-	2	1	-	-	4	2	2	1	-	1	1
P. felina * (n = 38)	1	1	1	1	1	-	-	4	4	1	1	3	5	2	2	2	2	1	1	1	2
D. gonocephala ** (n = 81)	-	-	-	-	1	-	2	3	8	7	11	12	5	3	12	3	4	5	3	-	1
Phagocata vitta (n = 3)	-	-	1	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
Dendrocoelum spec. (n = 1)	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-

* One record for pH = 5.4 and pH = 8.8 ** One record for pH = 8.0

could only find *P. tenuis*, a species first recorded for the Netherlands by den Hartog (1962). Mur-Atzema (1965) also recorded *P. tenuis* from this locality, so that it is possible that Leentvaar & Schimmel have confused this species with *P. felina*. With respect to the locality near Winterswijk it must be mentioned that the exact source of this information could not be determined (den Hartog, pers. comm.)

The co-existence of rheophilous triclads and accompanying limnadophilous species.

In Table 1 the co-existence of the rheophilous triclad species with each other and with limnadophilous species in the Netherlands is given. From this table it can be seen that *Crenobia alpina* was often found alone or with *Dugesia gonocephala*, occasionally with *P. felina*, and only very rarely with limnadophilous species (in one locality with *Dendrocoelum lacteum* (O.F. Müller), which is of all limnadophilous species the best adapted one to running waters). Also *D. gonocephala* mostly occurred alone; at a few localities it was accompanied by *C. alpina* and/or *P. felina*, and sometimes by *D. lacteum*, *Polycelis nigra* (O.F. Müller, 1773) and *Polycelis tenuis*. *P. felina* was found mostly alone, further together with *Dugesia gonocephala*, and relatively often with limnadophilous species. Surprisingly, *P. felina* and *C. alpina* occurred together the least number of times.

The co-existence, or otherwise, of different species depends on several factors, which may influence each other in a complex way. Competition between the different species in one possibility (Lock & Reynoldson 1976) by which, dependent of the circumstances, one species or another becomes dominant or even eliminates its competitor. According to Lock & Reynoldson (1976) competition between *P. felina* and *C. alpina* is very likely based on similar food preferences (Oligochaeta, *Gammarus*, Plecoptera and Trichoptera) while when *P. felina* diminished in a locality where formerly it was dominating, *C. alpina* became more numerous.

Besides competition, however, other factors may also determine the distribution, such as temperature sensitivity combined with a high oxygen need of the rheophilous species (den Hartog 1962, Russier-Delolme 1974). The adults can survive in a rather wide temperature range. The limits of distinct (infinite) survival of the adults with respect to the water temperature have been determined by Pattée (1966). For *C. alpina* he found an upper limit of 12-14 °C, for *P. felina* 16-17 °C and for *D. gonocephala* 20-21 °C (cf. the limnadophilous *P. nigra* 23-24 °C). Further laboratory experiments carried out by Pattée (1968, 1969) proved, that all species are able to survive much higher temperatures for a few days and that the reproductive capacity is temperature dependent.

The water temperatures measured on the Dutch localities of the three rheophilous triclads appeared not to differ significantly from a statistical point of view (Table 2). The maximum water temperatures at which the species were found, differ and are 14 °C for *C. alpina*, 15 °C for *P. felina* and 18 °C for *D. gonocephala*. These temperatures are below or similar to the upper limits as determined for the different species by Pattée (1966, 1968, 1969).

In the Netherlands the zonation as found by Voigt (1904) with *C. alpina* in the springs and upper course, with *P. felina* in the middle course and *D. gonocephala* further downstream, can hardly be confirmed. This is an indication that besides competition and temperature sensitivity also other factors are determining the distribution of these three species. It is known that *P. felina* rarely occurs in the chalk rich springs of South-Limburg (Redeke 1948, Cuppen 1978). The localities in southern South-Limburg are mainly situated on the sands of Aachen and Hervian sands which are poor in lime. Van Oye (1941) found in Belgium for *P. felina* the widest pH-range, viz., from 4.8 to 8.2 (*C. alpina* from 7.0 to 8.3, *D. gonocephala* from 6.3 to 8.4). This is in conformity with measurements in the Netherlands (Table 3). The chemical composition of the water, reflected by the pH, is for the distribution of the rheophilous triclads, however, in most cases of indirect importance. Flössner (1959) for example recorded *C. alpina* even at a minimum pH of 5.0

(Erzgebirge, D.D.R.). It can be concluded that at a pH lower than 6.2 *P. felina* can occur in the Netherlands, but *C. alpina* and *D. gonocephala* then are absent. The hydrological situation, however, probably is much more important for the distribution of the rheophilous triclads (Oomen & Geelen 1966). This is certainly the cause of the absence of rheophilous triclads in brooks flowing in the moraine area of the province of Drenthe (Oomen & Geelen 1966, Mur-Atzema & Mur 1967, van Gijsen & Claassen 1978).

Besides temperature and competition for food, adaptation to stream velocity and to the substrate plays a rôle. *C. alpina* can maintain itself better on steep gradients and in strong, fast running water with a coarse substrate than can *P. felina* (Lock 1975, Wright 1974). Such hydrological situations can be found in southern South-Limburg, but outside this area of chalk hills such conditions are rare in the Netherlands and occur only where springs come from the sandy moraine ridges which were cut off transversely by a river (Oomen & Geelen 1966). *D. gonocephala* is also a species adapted to strong running water and a situation with *C. alpina* in the spring area and the upper course combined with *D. gonocephala* is relatively frequently found in South-Limburg. Outside this area *D. gonocephala* is very rare. *P. felina*, however, occurs more in shallow gradients, as reflected in Table 1 by the more frequent occurrence of limnadophilous triclads in the same localities.

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