The influence of acidity and chlorinity on the distribution of Hydroporus species (Coleoptera, Dytiscidae) in the Netherlands

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The Influence of Acidity and Chlorinity on the Distribution of Hydroporus Species (Coleoptera, Dytiscidae) in the Netherlands.

by **J. G. M. Cuppen**

Abstract: 1. Adult water beetles were collected from 732 localities in the Netherlands. The distribution of eighteen species of the genus *Hydroporus* has been related to acidity and chlorinity by use of the Index of Representation (I. R.).

2. *H. tristis* (Payk.), *H. obscurus* Strm., *H. pubescens* (Gyll.), *H. gyllenhalii* Schiödte (= *H. piceus* Steph.), *H. melanarius* Strm. and *H. neglectus* Schaum are acidobiont species in the Netherlands and acidity forms a main environmental variable in their distribution. *H. scalesianus* Steph., *H. memnonius* Nicol. and *H. nigrita* (F.) are acidophilous species. *H. erythrocephalus* (L.), *H. umbrosus* (Gyll.) and *H. incognitus* Sharp are significantly over-represented in acid waters but have a wide tolerance. *H. striola* Gyll. and *H. dorsalis* (F.) are clearly over-represented at pH's between 6.1 and 7.5 (not significant). The very common *H. palustris* (L.) and *H. angustatus* Strm. are over-represented at pH's between 6.6 and 7.5 (not significant for *H. angustatus)* and they avoid acid waters. *H. tessellatus* Drap. is the only alkaliphilous species. *H. planus* (F.) is indifferent with respect to acidity.

3. *H. tessellatus* is halophilous and chlorinity is an important environmental variable for this species. The remaining species with the exception of *H. memnonius, H. nigrita, H. palustris* and *H. planus* are haloxenous.

4. Acidity explains more variation in the distribution patterns of *Hydroporus* spp. in the Netherlands than chlorinity.

Key words: Coleoptera Dytiscidae – *Hydroporus* spp. – acidity – chlorinity – distribution.

Introduction

The holarctic genus *Hydroporus* Clairville (Coleoptera; Dytiscidae) is comprised of 213 species (Franciscolo, 1979); it is the most diverse dytiscid genus in the Netherlands, with 24 species represented (van Nieukerken, 1982). The species inhabit a wide variety of habitats (e. g. peat-cuttings, brackish waters and brooklets).

This investigation is part of a greater study concerning the ecology and geographical distribution of aquatic beetles in the Netherlands. In this study the distribution of eighteen species of *Hydroporus* was related to pH and chlorinity; the other six species – *H. discretus* Fairm., *H. elongatulus* Strm., *H. glabriusculus* Aubé, *H. longulus* Muls., *H. notatus* Strm. and *H. rufifrons* (Duft.) – were omitted due to lack of data. Except for *H. discretus* these species are extremely rare in the Netherlands and known from only single or a few localities (Everts, 1903; van Nieukerken, 1979).

Relationships between species, pH and chlorinity, based on field data, only can be of a correlative nature. Although causal relationships can not be determined by analysis of correlations between species and environmental factors, useful predictions concerning the distribution of species in a certain area can be obtained and information about the co-existence or non-co-existence of species.

Acidity and chlorinity were chosen as environmental variables because they can be determined easily at low costs. Furthermore, many of the ecological data concerning relationships between species and habitat refer to acidity (acidophilous) or chlorinity (haloxenous, halophilous, halobiont) or this relationship (tyrphophilous, tyrphobiont, sphagnobiont) is indirectly involved (Hebauer, 1974).

Correlations between species and environmental variables only refer to the investigated area (in this study: the Netherlands), because a species can occur in different habitats or niches in different geographic areas due to interactions between environmental variables. This phenomenon is particularly noticeable at the boundary of the distribution of a species. For example, the distribution of *H. tessellatus* Drap. is centered in southern Europe (Zimmermann, 1931; Franciscolo, 1979) and it just reaches the south-western part of the Netherlands. In the Netherlands *H. tessellatus* is restricted to stagnant, brackish waters (this study). However, in southern Europe this species inhabits lotic and lentic waters and fresh as well as brackish waters (Guignot, 1947; Franciscolo, 1979).

Material and methods

Collecting methods

Adult water beetles were collected during the years 1978–1983 from 732 localities throughout the Netherlands, but mainly in the south-eastern part. Almost every available water type was sampled, although the number of samples collected from some water types (lakes and springs) was low.

The beetles usually were collected using a standard macrofauna-net (aparture 30 × 20 cm; mesh-size 0.5 mm), but in very shallow waters or in waters overgrown by emergent vegetation a kitchensieve (same mesh-size) was used. Species living at the water's edge were collected by trampling the borders in order to dislodge the beetles; floating specimens then were caught by hand. Mosses were rinsed in a white tray and large stones were inspected visually. Collections were either sorted in the field using a white tray or were transported in a plastic bag to the laboratory, where samples were sieved and sorted in a white tray, as soon as possible.

Specimens were collected for about 1–1½ h at most localities. Sometimes, however, a longer or shorter time was adopted, depending on abundance and diversity. Sampling was usually only qualitative, therefore, only presence/absence data for *Hydroporus* spp. were used.

Collections were made throughout the year but the number of observations from November to February was low.

Chemical measurements

Acidity was measured with a Metrohm Herisau (E588) pH meter, while chlorinity was measured titrimetrically according to Mohr. Analysis was conducted no later than 36 h after a collection was made. The values of pH and chlorinity were divided in classes (Table 1 and 2 respectively).

Analysis of distribution patterns

The distribution of *Hydroporus* spp. was related to pH and chlorinity using the Index of Representation (I.R.) (Hildrew & Townsend, 1976).

I.R. = $O - E/\sqrt{E}$

where O = number of observations of a certain species in a certain class of the factor considered, and E = expected number of observations.

The statistical significance was tested by the chi-squared test. Calculation of I.R. values is based on the null hypothesis (H_0) that a species has no preference or aversion towards certain classes of the factor considered and is represented in all classes equally. H_0 was accepted when the differences between observed and expected number of observations was not sufficient to obtain chi-squared values above the 5% level. H_0 was rejected when chi-squared values were higher than 5%.

When H_0 is rejected, this indicates under- or over-representation in one or more classes of the considered factor. Positive I.R. values indicate over-representation (in this study: preference) and negative values indicate under-representation (in this study: aversion). Following Tolkamp (1980) differences in I.R. values are considered to be significant when the values deviate 2 or more from zero. The Index of Representation has been used in stead of frequency distributions, because the number of observations in different classes is not equal and can lead to incorrect interpretations (Cuppen, 1983).

Results

Tables 1 and 2, respectively, give the number of observations for pH-classes and Cl^--classes and the distribution of the number of observations of the *Hydroporus* spp. over these classes. These summaries of the field data are the data set for the calculations of the I.R. values. They show that *H. palustris* (L.) is the most commonly collected species of the genus over a wide range of pH and Cl^- values; it is present in more than 60% of the samples, while *H. tessellatus* is present in less than 2% of the collections. Most *Hydroporus* spp. show a wide range for both parameters, though the number of observations for pH higher than 7.5 and chlorinities higher than 200 mg l^{-1} is low. *H. tessellatus* has only been found at pH higher than 6.5 and chlorinities higher than 100 mg l^{-1}.

pH	3.1–4.0	4.1–5.0	5.1–6.0	6.1–6.5	6.6–7.0	7.1–7.5	7.6–8.0	>8.1
pH-classes	1	2	3	4	5	6	7	8
N	33	55	54	105	184	165	73	62
H. angustatus	4	10	20	50	84	76	22	17
H. dorsalis	1	2	5	14	21	14	2	1
H. erythrocephalus	19	27	17	24	33	24	6	3
H. gyllenhalii	15	21	10	5	2	1	–	1
H. incognitus	11	23	13	25	19	10	–	2
H. melanarius	12	7	13	7	2	–	–	–
H. memnonius	5	12	18	27	22	10	4	8
H. neglectus	9	12	16	8	5	2	–	–
H. nigrita	2	3	9	19	20	13	5	3
H. obscurus	8	7	5	–	1	–	–	–
H. palustris	7	13	23	62	141	130	52	41
H. planus	8	16	15	24	37	40	20	10
H. pubescens	12	20	3	6	6	2	–	1
H. scalesianus	3	7	6	13	10	5	1	1
H. striola	3	1	8	17	27	21	5	3
H. tessellatus	–	–	–	–	2	3	2	7
H. tristis	20	30	12	8	11	13	1	3
H. umbrosus	10	24	18	24	33	26	4	4

Tab. 1: Number of observations for pH-classes (N) and number of observations of Hydroporus spp.

Cl⁻ (mg l⁻¹)	<15	15–30	30–45	45–60	60–75	75–100	100–200	>200
Cl⁻-classes	1	2	3	4	5	6	7	8
N	56	124	139	125	92	71	64	61
H. angustatus	6	51	62	43	44	34	26	17
H. dorsalis	3	7	17	11	8	8	5	–
H. erythrocephalus	38	38	23	10	23	12	7	2
H. gyllenhalii	19	12	12	6	3	3	–	–
H. incognitus	17	25	30	8	12	7	3	2
H. melanarius	5	14	11	6	3	1	1	–
H. memnonius	3	24	28	19	9	5	8	10
H. neglectus	4	16	19	8	4	1	–	–
H. nigrita	2	16	20	10	11	6	3	6
H. obscurus	13	6	1	–	1	–	–	–
H. palustris	14	63	82	79	74	55	54	46
H. planus	13	27	26	27	24	12	17	24
H. pubescens	18	14	9	2	4	3	–	–
H. scalesianus	8	12	8	7	4	6	1	–
H. striola	2	9	21	17	17	11	5	3
H. tessellatus	–	–	–	–	–	–	2	12
H. tristis	31	25	14	8	12	7	–	–
H. umbrosus	31	20	33	19	20	17	2	1

Tab. 2: Number of observations for Cl⁻-classes (N) and numbers of observations of Hydroporus spp.

In table 3, the I.R. values of the *Hydroporus* spp. with respect to pH are given. This table shows that most species have significant preferences and/or aversions to certain pH-classes. Two species have no significant I.R. values: *H. dorsalis* (F.) and *H. planus* (F.). For the last mentioned species the I.R. values do not deviate much from zero and one may call this species indifferent with respect to pH. The other species, including *H. dorsalis* show a logical arrangement of the I.R. values, though these values are not always significant. It means that acidity is one of the factors that influence the species composition in a certain water body. The importance of acidity as environmental variable for a species can be deduced from the deviations of the I.R. values from zero and the number of pH-classes between significantly positive and significantly negative values, that is the smaller this number the more important is acidity as environmental variable for that species.

On the basis of the I.R. values the species can be arranged in a way that they form a list from species mainly living in acid waters to species mainly living in alkaline waters. Acidity is an important environmental variable for species marked with a *.

pH	3.1–4.0	4.1–5.0	5.1–6.0	6.1–6.5	6.6–7.0	7.1–7.5	7.6–8.0	>8.1
H. angustatus	–2.45	–2.45	–0.20	1.47	1.51	1.52	–1.18	–1.43
H. dorsalis	–1.04	–1.18	0.27	1.83	1.52	0.12	–1.63	–1.81
H. erythrocephalus	4.60	4.56	1.69	0.23	–0.89	–1.79	–2.37	–2.77
H. gyllenhalii	7.94	8.29	2.94	–1.03	–3.18	–3.23	–2.34	–1.70
H. incognitus	2.94	5.48	1.95	2.65	–1.36	–2.75	–3.21	–2.28
H. melanarius	7.46	2.23	5.73	0.46	–2.59	–3.04	–2.02	–1.86
H. memnonius	0.10	1.42	3.63	3.02	–0.91	–2.85	–2.02	–0.33
H. neglectus	4.34	4.09	6.20	0.19	–2.24	–2.84	–2.28	–2.10
H. nigrita	–0.74	–1.09	1.51	2.57	0.32	–0.91	–0.88	–1.31
H. obscurus	7.24	4.31	2.77	–1.74	–1.86	–2.18	–1.45	–1.33
H. palustris	–3.08	–3.75	–1.98	–0.65	2.11	2.34	0.75	0.19
H. planus	0.12	0.90	0.69	–0.08	–0.88	0.26	0.73	–1.16
H. pubescens	6.48	8.37	–0.36	–0.44	–1.85	–2.76	–2.23	–1.57
H. scalesianus	0.65	1.90	1.41	2.49	–0.46	–1.67	–1.68	–1.47
H. striola	–0.43	–2.13	0.69	1.37	1.21	0.41	–1.20	–1.57
H. tessellatus	–0.79	–1.03	–1.02	–1.42	–0.81	–0.09	0.51	5.33
H. tristis	7.40	8.33	1.77	–1.72	–2.75	–1.94	–2.81	–1.84
H. umbrosus	1.39	4.04	2.29	0.76	–0.50	–1.10	–2.72	–2.33

Tab. 3: The I.R. values for the Hydroporus spp. with respect to pH (significant values are underlined).

		"significant" over-representation	"significant" under-representation
	* *H. tristis*	≤5.0	>6.0
	* *H. pubescens*	≤5.0	>6.5
Acidobiont	* *H. obscurus*	≤6.0	>6.0
	* *H. gyllenhalii*	≤6.0	>6.5
	* *H. melanarius*	≤6.0	>6.5
	* *H. neglectus*	≤6.0	>6.5
	H. scalesianus	4.1–6.5	>7.0
Acidophilous	*H. memnonius*	5.1–6.5	7.1–8.0
	H. nigrita	5.1–6.5	not significant
	H. erythrocephalus	≤5.0	>7.0
	H. umbrosus	≤6.0	>7.5
	H. incognitus	≤6.5	>7.0
	H. dorsalis	6.1–7.0	>7.5
	H. striola	6.1–7.0	≤5.0 >7.5
	H. angustatus	6.1–7.5	≤5.0 >8.1
	H. palustris	6.6–7.5	≤6.0
Alkaliphilous	*H. tessellatus*	>7.5	≤6.5
Indifferent	*H. planus*		

H. pubescens (Gyll.), *H. tristis* (Payk.), *H. obscurus* Strm., *H. gyllenhalii* Schiödte (=*H. piceus* Steph.), *H. melanarius* Strm. and *H. neglectus* Schaum are considered acidobiont species, while *H. scalesianus* Steph., *H. memnonius* Nicol. and *H. nigrita* (F.) are acidophilous species. *H. erythrocephalus* (L.), *H. umbrosus* (Gyll.) and *H. incognitus* Sharp have a preference for acid waters, but a wide tolerance. *H. angustatus* Strm. and *H. palustris* (L.) are over-represented at pH's between 6.6 and 7.5 and they avoid waters with a pH below 5.0. *H. dorsalis* (F.) and *H. striola* Gyll. are over-represented at pH's between 6.1 and 7.0 and have a wide tolerance. *H. tessellatus* is an alkaliphilous species.

The I.R. values for the *Hydroporus* spp. with respect to chlorinity are given in table 4. No significant I.R. values have been obtained for *H. memnonius, H. nigrita* and *H. striola,* and only negative ones for *H. angustatus* and *H. dorsalis.* A comparison with table 3 shows that negative or positive I.R. values do not deviate much from zero, significant values most often do not deviate much from 2 and the number of Cl^--classes between significantly positive and significantly negative values is large. Four acidobiont species (*H. obscurus, H. pubescens, H. gyllenhalii* and *H. tristis)* and one acidophilous species (*H. scalesianus*) are significantly over-represented in waters very low in chlorinity (<15 mg l^{-1}) and are significantly under-represented in waters with a chlorinity >100 mg l^{-1}. For *H. obscurus* the under-representation is not significant due to the low number of observations for this species. The other acidobiont species (*H. melanarius* and *H. neglectus*) have significant positive I.R. values for somewhat higher chlorinities (15–45 mg l^{-1}), but the same significant aversion. *H. memnonius* and *H. nigrita,* both acidophilous species, have a non-significant over-representation for chlorinities between 15–45 mg l^{-1}. Their occurrence in waters with more than 200 mg Cl^-/l^{-1} is most interesting; this occurrence concerned a small number of ditches behind seadikes, where a permanent seepage of brackish water through the dikes exists. *H. incognitus, H. erythrocephalus* and *H. umbrosus* have significant preference for low chlorinities and significant aversion for chlorinities >100 mg l^{-1}. *H. palustris* and *H. angustatus* only have significant aversions for very low chlorinities (<15 mg l^{-1}). *H. planus* and *H. tessellatus* have a significant preference for chlorinities above 200 mg l^{-1}, but the tolerance for lower chlorinities is great in case of *H. planus. H. tessellatus* is the only halophilous species in the Netherlands. Summarizing, all species except *H. memnonius, H. nigrita, H. palustris* and *H. planus* are haloxenous and *H. tessellatus* is halophilous.

Cl^- (mg l^{-1})	<15	15–30	30–45	45–60	60–75	75–100	100–200	>200
H. angustatus	–3.36	0.44	1.13	–0.77	1.41	1.25	0.25	–1.36
H. dorsalis	–0.71	–0.95	1.73	0.29	0.21	0.95	–0.07	–2.22
H. erythrocephalus	7.69	2.37	–1.12	–3.15	0.86	–0.74	–1.74	–3.01
H. gyllenhalii	7.21	0.88	0.48	–1.11	–1.49	–1.01	–2.19	–2.14
H. incognitus	3.21	1.76	2.31	–2.32	–0.30	–0.97	–2.02	–2.26
H. melanarius	1.05	2.68	1.15	–0.38	–0.95	–1.49	–1.36	–1.85
H. memnonius	–1.79	1.43	1.75	0.21	–1.18	–1.65	–0.42	0.39
H. neglectus	0.01	2.42	2.90	–0.29	–0.99	–1.80	–2.13	–2.08
H. nigrita	–1.54	0.98	1.59	–0.74	0.56	–0.44	–1.37	–0.07
H. obscurus	8.99	1.29	–1.50	–1.89	–1.01	–1.43	–1.35	–1.32
H. palustris	–3.63	–1.81	–0.71	–0.08	2.00	1.44	2.06	1.13
H. planus	–0.00	–0.33	–1.10	–0.38	0.57	–1.10	0.55	2.61
H. pubescens	7.25	1.90	–0.16	–2.24	–0.91	–0.83	–2.09	–2.04
H. scalesianus	2.39	1.51	–0.25	–0.30	–0.74	0.73	–1.51	–1.96
H. striola	–1.77	–1.42	1.21	0.65	1.93	0.96	–0.89	–1.53
H. tessellatus	–1.03	–1.54	–1.63	–1.55	–1.33	–1.16	0.70	10.03
H. tristis	8.66	2.11	–1.03	–2.10	–0.05	–0.78	–2.91	–2.84
H. umbrosus	6.06	–0.86	1.12	–1.10	0.48	0.84	–2.97	–3.16

Tab. 4: The I.R. values for the Hydroporus spp. with respect to Cl^- (significant values are underlined).

Discussion

Knowledge of larval habitat requirements is necessary for a detailed description of the habitat(s) of a certain species (Galewski, 1971), but, so few *Hydroporus* larvae have been described (Nilsson, 1982), that habitat(s) of the larvae cannot be determined for the moment. According to Jackson (1952) adults of many water beetles are very mobile (good developed wings and wing musculature) and they form an unstable part of macrofauna-coenoses. However, the restriction of many *Hydroporus* spp. to certain habitats is so evident, that, in general, their great migratory capacity (e. g. Galewski, 1971; Drost & Schreijer, 1978) must be doubted. If mobility is assumed, a mechanism for detection of required water types must exist or, perhaps, species fall prey to fish, when colonizing unsuitable habitats, as shown by Macan (1976) for Corixidae. This means that larvae will be found only in habitats where the adults form reproducing populations, at least during part of the year. Only species with a great migratory capacity (*H. planus, H. tessellatus*) can form populations in other habitats than their breeding grounds.

Hebauer (1974) provides ecological nomenclature of water beetles according to the following definitions:

Tyrphobiont species: restricted to habitats with peaty soils

Tyrphophilous species: mainly in habitats with peaty soils, but occasionally elsewhere

Acidophilous species: mainly living in weakly acid waters.

Two characteristics refer to the preferred soil as the main characteristic of the distribution pattern of a species and all three characteristics – though indirectly – refer to acidity. Tyrphobiont – in terms of acidity – can be translated into: restricted to very acid waters, and tyrphophilous into: mainly in very acid waters, but occasionally elsewhere (e. g. *H. erythrocephalus* and *H. incognitus* in this study). When this assumption is made a comparison for some species in different parts of their geographical distribution area can be made.

	Netherlands this study	Germany HEBAUER (1974) SCHAEFLEIN (1971)	Sweden NILSSON (1979)
H. obscurus	acidobiont	tyrphobiont	tyrphophilous
H. tristis	acidobiont	tyrphophilous	tyrphophilous
H. melanarius	acidobiont	acidophilous	tyrphophilous
H. umbrosus	"tyrphophilous"	tyrphophilous	tyrphophilous
H. erythrocephalus	"tyrphophilous"	acidophilous	tyrphophilous
H. scalesianus	acidophilous	?	tyrphobiont
H. angustatus	not acidophilous	acidophilous	tyrphophilous

This comparison clearly shows that the pH preference of a number of species of *Hydroporus* varies geographically. A better comparison only will be possible when more exact definitions for soil conditions (i.e. definitions not subject to a personal assessment based on the presence/absence of *Sphagnum)* are designed or when actual measurements of the acidity in other countries are available.

Concerning chlorinity, the data for the *Hydroporus* spp. in the Netherlands are not in contradiction with data from literature as most species are haloxenous or – more or less – salt tolerant. In the Netherlands, acidity better describes the distribution patterns of *Hydroporus* spp. than chlorinity.

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