Zeitschrift: Entomologica Basiliensia
Herausgeber: Naturhistorisches Museum Basel, Entomologische Sammlungen
Band: 11 (1986)

Artikel: Association analysis of water beetle communities (Coleoptera: Dytiscidae et Haliplidae)

Autor: Flechtner, G.

DOI: https://doi.org/10.5169/seals-980552

Entomologica Basiliensia	11	297–308	1986	ISSN 0253-2484

Association Analysis of Water Beetle Communities Coleoptera: Dytiscidae et Haliplidae)

by **G. Flechtner**

Abstract: For the first time quantitative samples of water beetles from stagnant waters have been recorded. Occurrence in dependence of abiotic and biotic environmental parameters was investigated.
On family level dytiscids are limited by a few factors only. Therefore they are present in a great number of different small waters, where they are the dominant macroscopic group beside larvae of Diptera. On species level many factors are suitable for mutual separation. The whole family of Haliplidae is confined to productive waters by many parameters.
The association of two species reflects their environmental demands. Complexes of environmental parameters are regulating occurrence and abundance of species in certain manners and are in this way implying structure of water beetle communities. Association analysis is a suitable mean to explain this complex connections.

Key words: Coleoptera Dytiscidae, Haliplidae – association-coefficients – quantitative sampling – environmental parameters – community structure – limiting factors – patterns of association.

Introduction

“Die jeweilige Käferfauna ist aufgrund zahlreicher Lokalfaktoren mit anderen Gebieten nicht vergleichbar.”[1] BURMEISTER (1982) is writing on the aquatic coleopteran fauna of the Murnauer Moos. He is evoking a problem, which generally is important for the analysis of multi-species-systems.

Faunistic-ecological investigations of water beetles have been made for several regions (e.g. ALFES & BILKE, 1977; DANNAPFEL, 1977; DETTNER, 1976; GASSMANN, 1974; HEBAUER, 1979; MEYER & DETTNER, 1981; SCHÄFLEIN, 1974; SEEGER, 1971). Nevertheless, factors limiting occurrence, abundance and community structure are fairly unknown. Because ecological research normally is restricted to small areas, results are not transferable to other ones (an exception: CUPPEN, 1983). Faunistically orientated investigations are incomplete, because the number of underlaying parameters is too small.

---

[1] Each fauna of beetles is not comparable with that of other regions, because there are too many local factors.

This paper is part of a work on structure and function of water beetle communities and shows first elements of association analysis based on quantitative sampling, previously unknown for water beetles.

Material and methods

Quantitative samples (n = 195) have been made in the years 1978 and 1979 by the means of an aluminium cube (80 × 80 × 80 cm, bottom and surface open). Stagnant waters in Southern Germany (Fig. 1) in biogeographic regions "Zentrales Mittelgebirge" and "Alpen" (Illies, 1967) have been investigated. Height above sea-level reached from 89 up to 2054 meters.

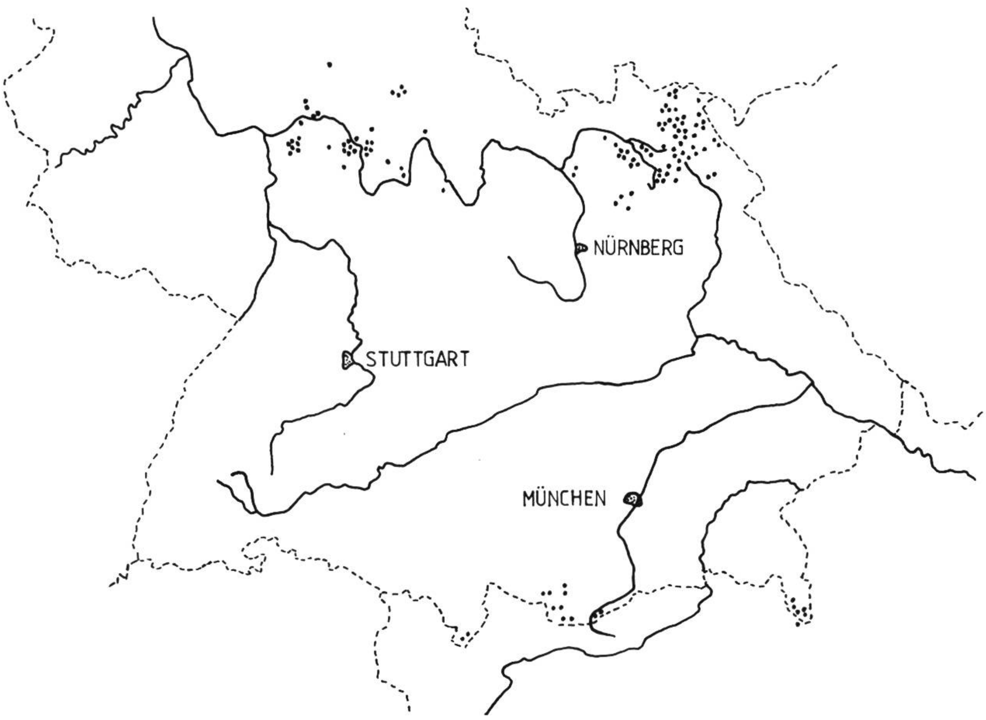

Fig. 1: Geographical distribution of samples.

For each sample 52 parameters have been determined, describing physical and chemical properties of the water, morphological and edaphic structure as well as the geographic and the climatic situation. Coinhabitants have been recorded semiquantitatively. Structure of water beetle communities was analysed quantitatively by means of association-coefficients C_8 according to Hurlbert (1969) and C_9 according to SOUTHWOOD (1966) respectively HALBACH (1972). Only species, which have at least one significant association are considered (Tab. 1).

Tab. 1: Number of species and abundance of their occurrence (only species with significant associations)

number of species		abundance of occurrence*	total number of individuals
	Dytiscidae		
1	Hyphydrus ovatus (L.)	18	101
2	Guignotus pusillus (F.)	19	154
3	Coelambus impressopunctatus (Schall.)	7	35
4	Hygrotus decoratus (Gyll.)	12	255
5	Hygrotus inaequalis (F.)	26	316
6	Hygrotus versicolor (Schall.)	14	383
7	Hydroporus dorsalis (F.)	8	178
8	Hydroporus angustatus Strm.	16	88
9	Hydroporus tristis (Payk.)	26	186
10	Hydroporus striola Gyll.	8	248
11	Hydroporus palustris (L.)	98	2971
12	Hydroporus incognitus Shp.	45	144
13	Hydroporus erythrocephalus (L.)	31	316
14	Hydroporus nigrita (F.)	32	60
15	Hydroporus foveolatus Heer	13	153
16	Hydroporus planus (F.)	54	964
17	Hydroporus discretus Fairm.	14	44
18	Hydroporus ferrugineus Steph.	6	16
19	Hydroporus memnonius Nicol.	42	146
20	Hydroporus melanarius Strm.	14	193
21	Graptodytes pictus (F.)	37	416
22	Noterus clavicornis (Deg.)	22	197
23	Noterus crassicornis (Müll.)	22	613
24	Laccophilus minutus (L.)	(30)	131
25	Agabus guttatus (Payk.)	(15)	123
26	Agabus bipustulatus (L.)	(89)	433
27	Agabus melanarius Aubé	(23)	309
28	Agabus sturmi (Gyll.)	(50)	422
29	Agabus affinis (Payk.)	14	150
30	Agabus congener (Thunb.)	(14)	36
31	Agabus undulatus (Schrank)	(12)	72
32	Ilybius fuliginosus (F.)	(60)	235
33	Ilybius ater (Deg.)	(18)	58
34	Rhantus pulverosus (Steph.)	16	31
35	Colymbetes fuscus (L.)	13	117
36	Acilius sulcatus (L.)	(12)	44
37	Dytiscus marginalis L.	(21	29

number of species		abundance of occurrence*	total number of individuals
	Haliplidae		
1	Haliplus lineatocollis Mrsh.	22	288
2	Haliplus wehnkei Grh.	26	541
3	Haliplus ruficollis Deg.	33	383
4	Haliplus heydeni Wehnk.	33	466
5	Haliplus flavicollis Strm.	21	165

* Numbers in parathesis: there is at least one sample, where only larvae had been found.

Results and discussion

Structuring factors on family level

The parameter "daily length of shading" (light intensity, Fig. 2) has been selected to demonstrate the typical behaviour of dytiscids in relation to environmental factors. Mean values for single species are scattered in a wide range around the mean value for all sampling units. In general, the presence of predaceous diving beetles does not depend on light intensity, but for individual species this can be an important fac-

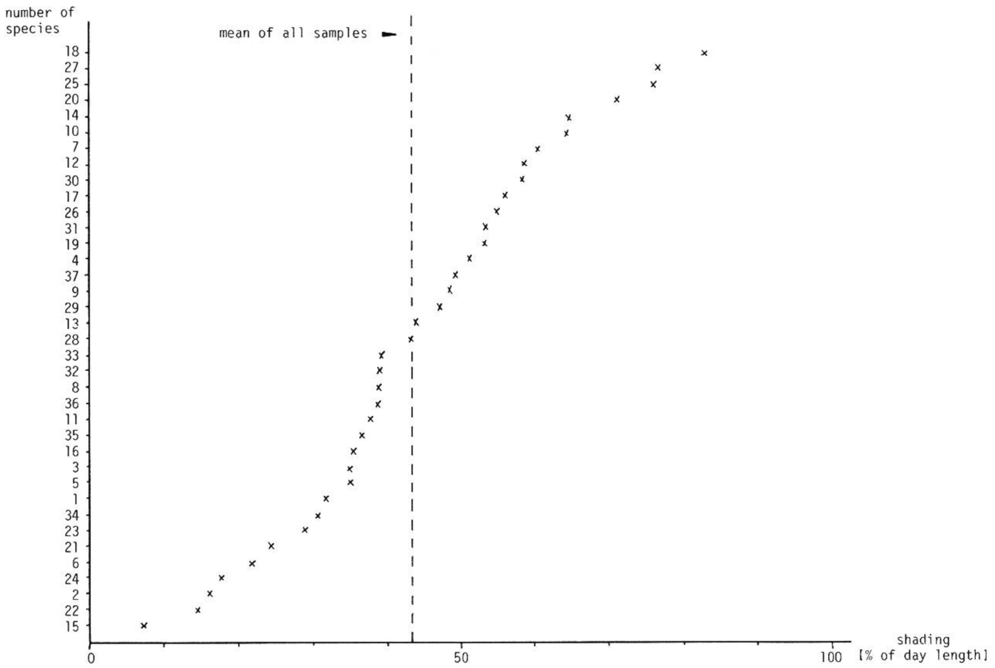

Fig. 2: Dytiscidae and their occurrence in relation to light intensity, measured by daily length of shading. Every cross shows the mean for one species. To its identification and abundance look on the table.

tor. Often parameter mean values for species show large standard deviations. Nevertheless many factors can be used, to separate species in a statistical significant manner.

Still several dependencies on family level can be detected. It concerns the parameters: altitude, square dimension of waterbodies, influence by wind, and degree of plant cover (Figs 3 and 4). Generally dytiscid beetles prefer smaller waters, the smaller Haliplidae greater ones. Additionally dytiscids favour lower altitudes, with little influence by wind and a high degree of plant cover. The latter confirms an assumption of KOCH (1968).

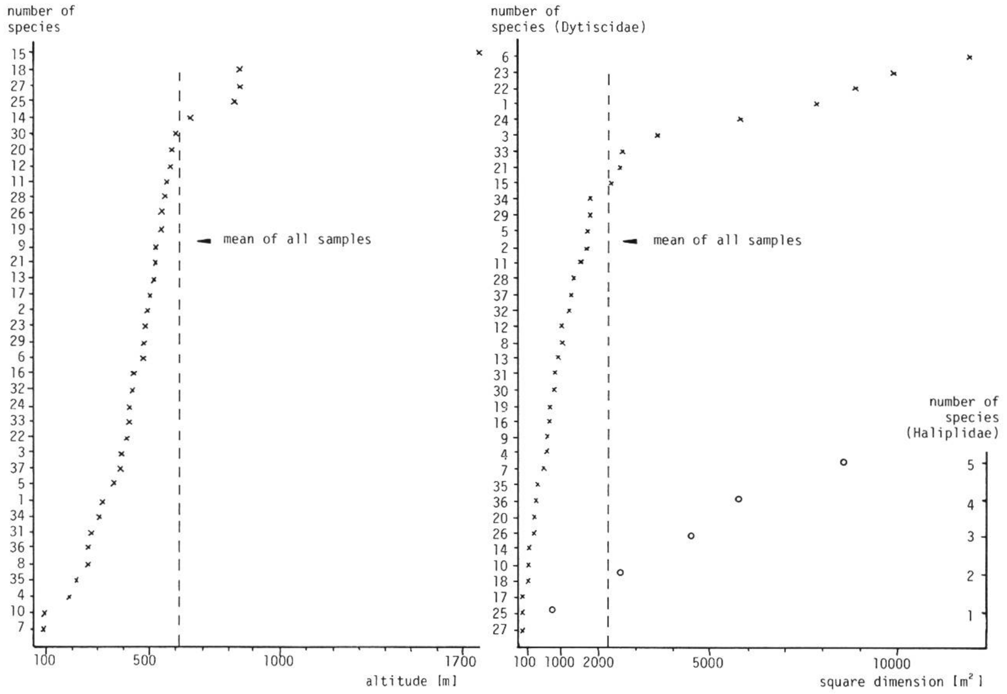

Fig. 3: The occurrence of Dytiscidae in relation to altitude and square dimension of waterbodies. In the last case Haliplidae are included. Every cross (circle) shows the mean for one species. To its identification and abundance look on the table.

In opposition to LARSON & COLBO (1983), who assumed a negative correlation between dytiscids and larvae of dragonflies, relationships to other groups of animals are not present on family level. But there are two exceptions. The abundance of larvae of caddisflies is negatively correlated with the occurrence of predaceous water-beetles. Like dytiscids dipteran larvae (mainly chironomids) are found in nearly all samples. They may play an important role in nutrition of beetles.

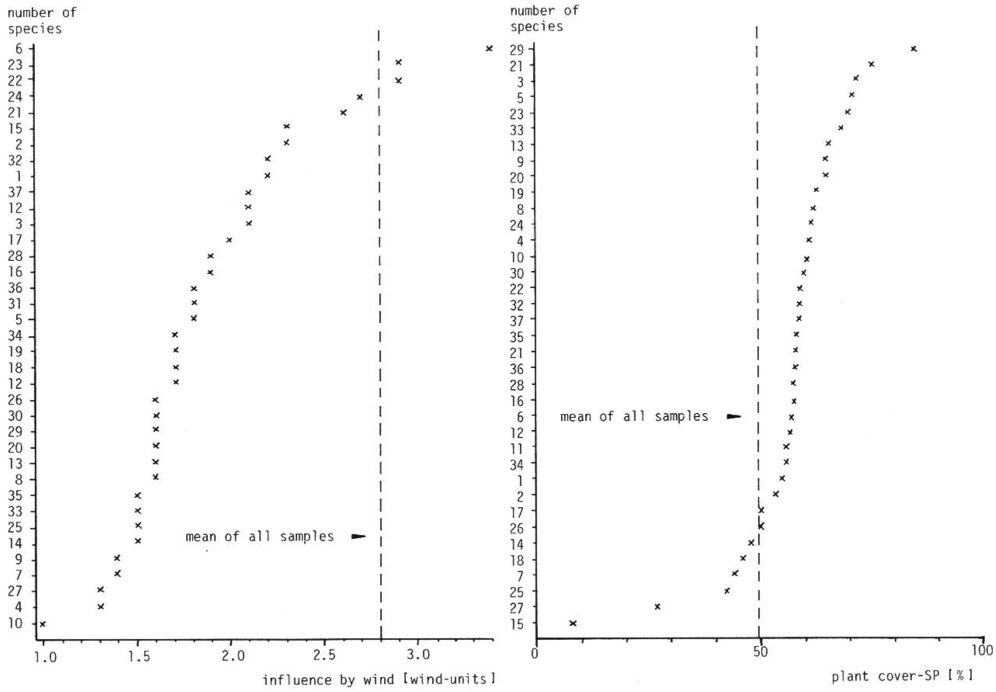

Fig. 4: The occurrence of Dytiscidae in relation to influence by wind and plant cover of sampling unit (SP). Every cross shows the mean for one species. To its identification and abundance look on the table.

Shallow litoral zones of standing permanent small waters are governed by diytiscids. Beside dipteran larvae they are the dominating macroscopic group, at least concerning their number of presence (Fig. 5). Therefore they seem to be suitable as a tool for a differentiated classification of such types of waterbodies and proofing their water quality.

Haliplidae are confined to a much lower number of waters (Fig. 5). Many environmental parameters have a trend to limit their occurrence. Similar like Dytiscidae crawling water beetles prefer lower altitudes and high degrees of plant cover. But tendencially they are settling in larger waterbodies (Fig. 3). Light intensity should be high as well as value of pH. There is a high demand for oxygen, combined with the existence of green algae.

A positive connexion seems to exist between the occurrence of Haliplidae and other groups, like larvae of Odonota, larvae of Ephemoptera and Plecoptera, water-inhabiting Heteroptera, Hydrophilidae (s.l.), larvae of Megaloptera, Amphibia & Reptilia, and Pisces. Whereas the abundance of larvae of Trichoptera is negatively correlated with the presence of Haliplidae. The mean values of all five species showing on association have a corresponding behaviour in relation to the factors mentioned above. They are all together either under or above the means

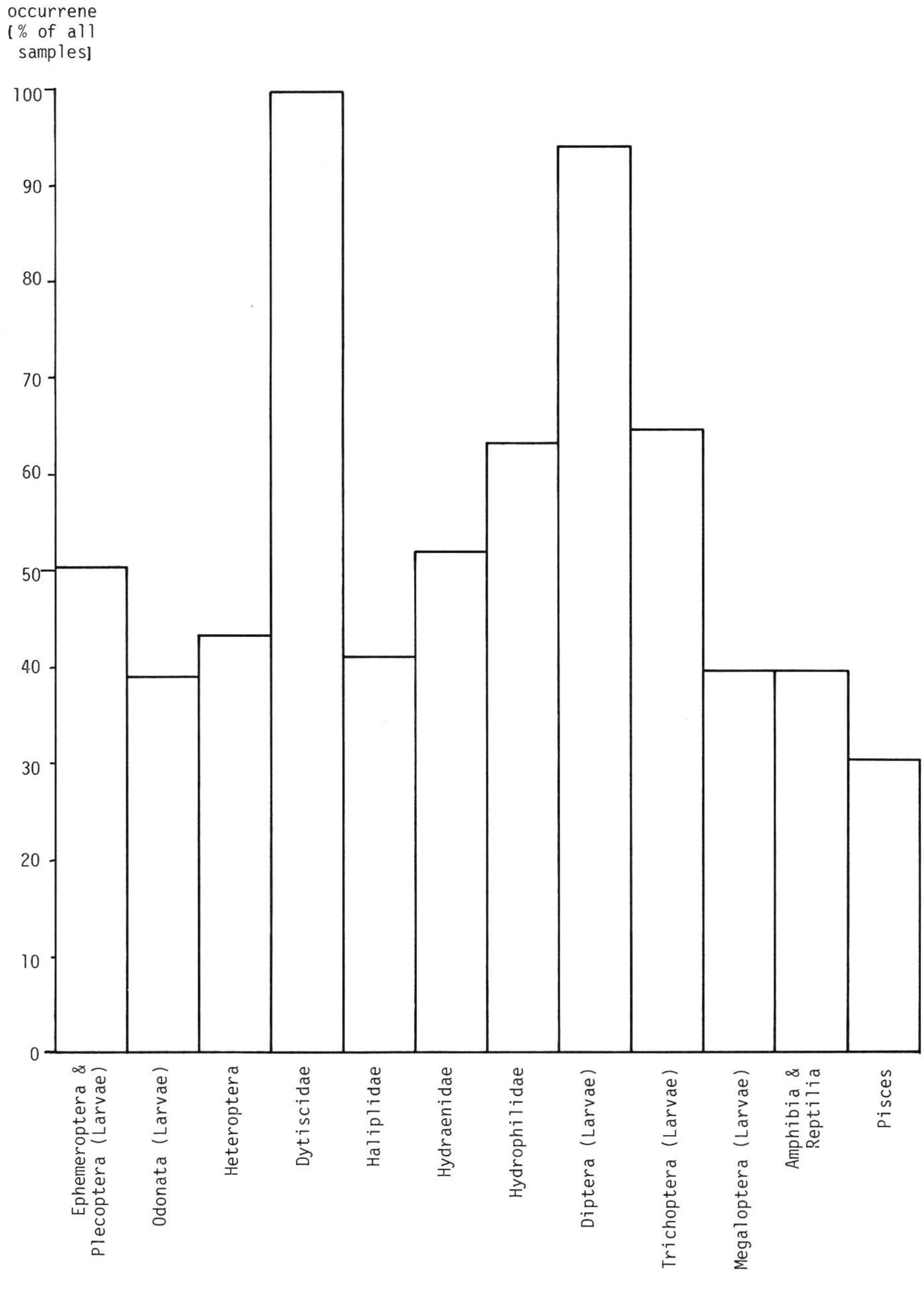

Fig. 5: Procentual occurrence of macroscopic groups in relation to all samples. The number of all samples was n = 195.

of all samples according to the respective factor. There is only one exception: square dimension of waters (cf. Fig. 3).

In general, the family of Haliplidae is showing affinity to waters with high productivity.

Association of two species

The characterization of waters for two negatively associated species (Fig. 6: *Hydroporus nigrita* F. and *Noterus clavicornis* (Deg.); $C_8 = -1.0$, $C_9 = -1.0$, $p<0.03$) shows, that they are avoiding each other, because they have different abiotic claims. Positively associated species (Fig. 7: *Hydroporus tristis* Payk. and *Hydroporus erythrocephalus* (L.); $C_8 = +0.54$, $C_9 = +0.27$, $p<0.001$) on the other hand are far-ranged parallelly in their environmental demands. This may be the only reason for their joint occurrence. Hutchinson index for both species is 1.36. It is imaginable, that different sizes lead to an utilization of different food niches (Topp, 1981).

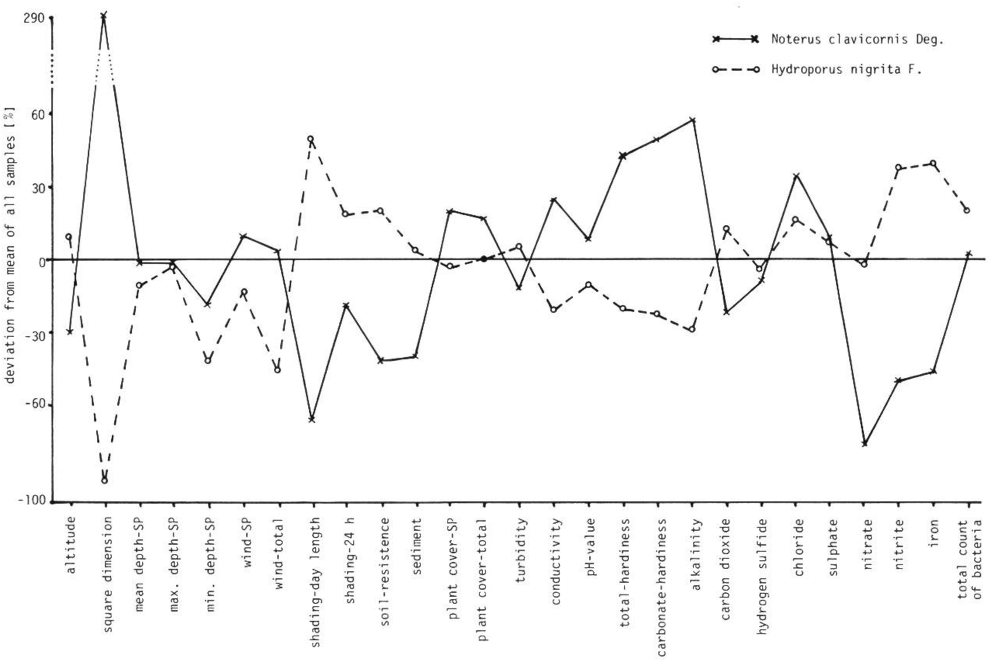

Fig. 6: Negative association of two species and characterization of waters, which are inhabited.

The examples demonstrate: associations are constituted either by similar or by different demands to environmental factors.

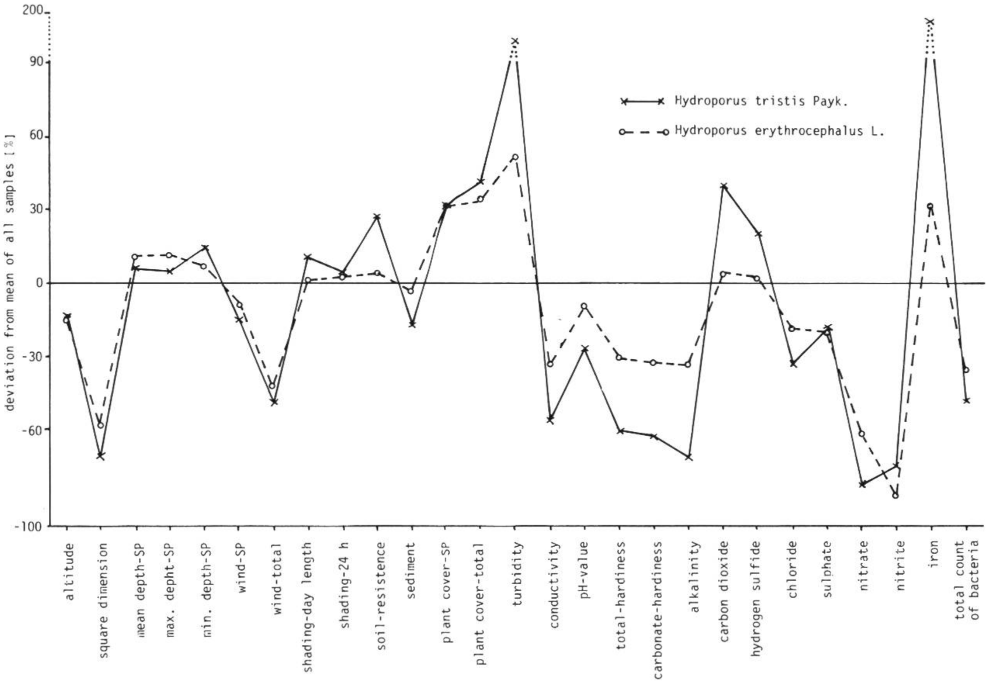

Fig. 7: Positive association of two species and characterization of waters, which are inhabited.

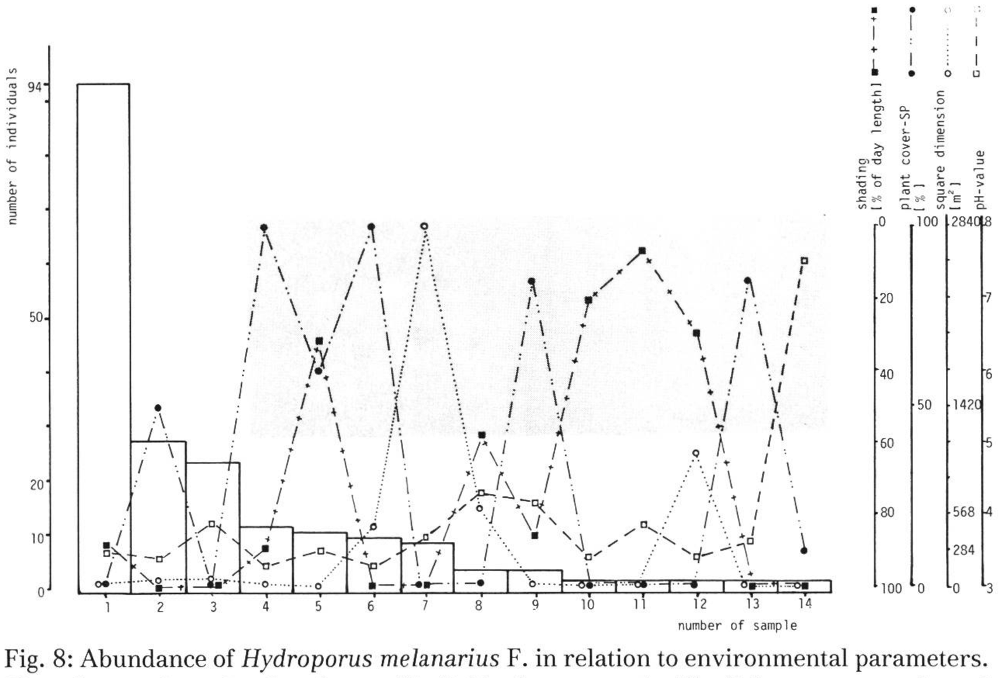

Fig. 8: Abundance of *Hydroporus melanarius* F. in relation to environmental parameters. The columns show the abundance of individuals per sample. The light-grey puncted areal demonstrates the pessimal region.

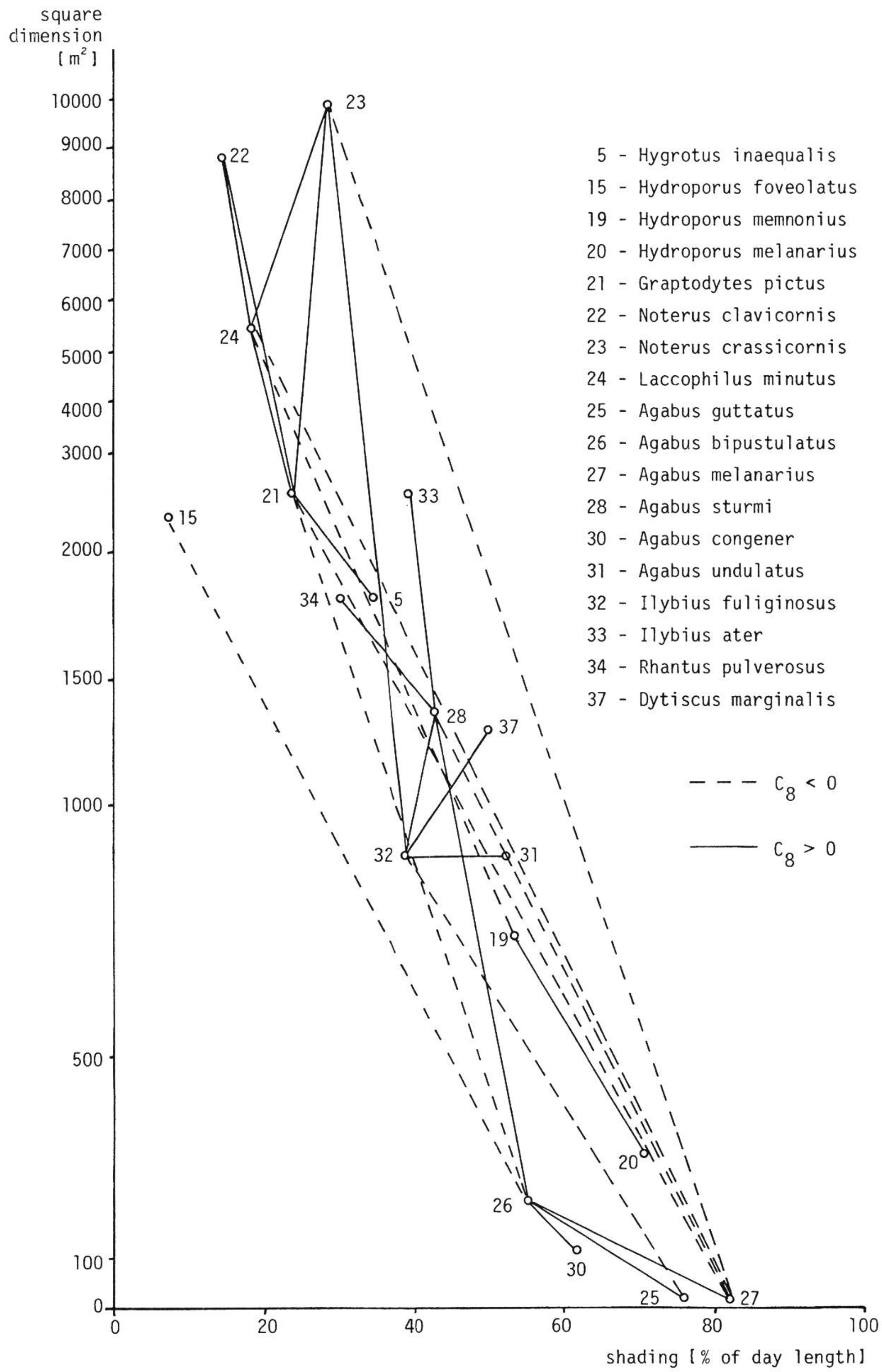

Fig. 9: Square dimension and light intensity (measured by daily length of shading) – resulting patterns of association. Full lines show a positive, dotted ones a negative association between two species.

Occurrance and abundance of particular species

All investigated species show that occurrence and abundance are regulated by a complex of factors. As example *Hydroporus melanarius* Strm. is taken (Fig. 8). High numbers of individuals are attainted only, if parameters – in our example light intensity, degree of plant cover, square dimension of waters, and value of pH – are all outside of a pessimal region. Presence of *Hydroporus melanarius* depends on low values of pH. But the occurrence of this species is not necessarily a proof for a low pH-value (see Fig. 8: waterbody n. 14).

One of the consequences is therefore, that Dytiscidae only can be used as bioindicators, if quantitative samples are taken. A similar statement for Elmidae was given by Knie (1977).

Structure of water beetle communities and patterns of association

In figure 9 a part of the community structure depending on square dimensions of waterbodies and light intensity of sampling point is presented examplaryly. As theory is demanding, only species are positively associated, which possess similar claims to both parameters. Relations are in those cases negative, in which demands to both factors are contrasting.

By means of association analysis structures of communities can be detected, which are based either on similarity or on dissimilarity of environmental parameters (abiotic and biotic ones).

Despite a great variability in individual data water beetles depend in a very characteristic manner on environmental features. This can be shown for the occurrence of families as well as for the much differentiated case of the occurrence of particular species and their interactions. Finally we can see a complex pattern of environmental factors regulating abundance of individuals. Association analysis, which contain the investigation of a sufficient quantity of waterbodies and a high number of parameters, are able to show this and to give useful explanations.

References

Alfes, C. & Bilke, H. (1977): *Coleoptera Westfalica: Familia Dytiscidae.* Abh. Landesm. Naturk. Münster/Westf. *39 (3/4):* 3–109.

Burmeister, E.-G. (1982): *Die aquatische Coleopterenfauna des Murnauer Mooses (Coleoptera: Haliplidae, Gyrinidae, Noteridae, Dytiscidae, Hydraenidae, Helophoridae, Hydrophilidae).* Entomofauna, Suppl. *1:* 227–261.

Cuppen, J. G. M. (1983): *On the habitats of three species of the genus Hygrotus Stephens (Coleoptera: Dytiscidae).* Freshwater Biol. *13 (6):* 579–588.

DANNAPFEL, K.-H. (1977): *Faunistik und Ökologie von Wasserkäfern im Naturschutzgebiet "Hördter Rheinaue" b. Germersheim (Insecta: Coleoptera).* Mitt. Pollichia *65:* 5–81.

DETTNER, K. (1976): *Populationsdynamische Untersuchungen an Wasserkäfern zweier Hochmoore des Nordschwarzwaldes.* Arch. Hydrobiol. *77 (3):* 375–402.

GASSMANN, M. (1974): *La Faune des Coléoptères Aquicoles du Marais de Kloten.* Diss. ETH 5232 (Zürich). 166 pp.

HALBACH, U. (1972): *Assoziationskoeffizienten dreier planktonischer Rotatorienarten im Freiland und ihre Deutung aufgrund interspezifischer Beziehungen (Konkurrenz, Räuber-Beute-Beziehung).* Oecologia *9:* 311–316.

HEBAUER, F. (1979): *Beitrag zur Faunistik und Ökologie der Elminthidae und Hydraenidae in Ostbayern (Coleoptera).* Mitt. Münchner Entomol. Ges. *69:* 29–80.

HURLBERT, S.H. (1969): *A coefficient of interspecific association.* Ecology *50 (1):* 1–9.

ILLIES, J. (1969): *Limnofauna Europaea.* G. Fischer, Stuttgart.

KNIE, J. (1976): *Ökologische Untersuchung der Käferfauna von ausgewählten Fliessgewässern des Rheinischen Schiefergebirges (Insecta: Coleoptera).* Decheniana (Bonn) *130:* 151–221.

KOCH, K. (1971): *Vergleichende Untersuchung über die Bindung aquatiler Koleopteren an ihre Lebensräume im Neusser Raum.* Decheniana (Bonn) *124 (2):* 70–112.

LARSON, D.J. & COLBO, M.H. (1983): *15. The aquatic insects: biogeographic considerations.* In: *Biogeography and Ecology of the Island of Newfoundland* (South, G.R., ed.) Junk Publ., The Hague. pp. 593–677.

MEYER, W. & DETTNER, K. (1981): *Untersuchungen zur Ökologie und Bionomie von Wasserkäfern der Drover Heide bei Düren (Rheinland).* Decheniana (Bonn) *134:* 274–291.

SCHAEFLEIN, H. (1961): *Halipliden und Dytisciden aus der Umgebung Straubings.* Mitt. Münchner Entomol. Ges. *51:* 124–149.

SEEGER, W. (1971): *Die Biotopwahl bei Halipliden, zugleich ein Beitrag zum Problem der syntopischen (sympatrischen s. str.) Arten (Haliplidae; Coleoptera).* Arch. Hydrobiol. *69 (2):* 155–199.

SOUTHWOOD, T.R.E. (1966): *Ecological Methods.* Methuen, London.

TOPP, W. (1981): *Biologie der Bodenorganismen.* UTB, Quelle & Meyer, Heidelberg.

Author's address:
Günter Flechtner
Zoologisches Institut, Fachbereich Biologie
J.W. Goethe-Universität
Siesmayerstrasse 70
D-6000 Frankfurt/M (FRG)