EPIPHYTIC AND SEDIMENTARY DIATOMS IN RELATION TO PHOSPHORUS, NITROGEN AND PHYTOPLANKTON IN NON-ACID LAKES AND PONDS (FLANDERS, BELGIUM)

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Very different ‘communities’ can be targetted in lake-phytobenthos monitoring (Table 1). This inevitably affects the perception of ecological status. Here, the response of diatoms in superficial *littoral surface sediment* and in the *epiphyton* to some eutrophication-related water column variables is examined, focussing on non-acid standing fresh waters in lower Belgium.

Table 1. Some of the more prominent differences between diatom assemblages on hard substrates and in recently deposited soft sediments.

	epilithon and epiphyton	surface sediment assemblages
• species richness, diversity	lower	higher
• temporal integration	≤ months; lower proportion of dead cells	≤ years; larger proportion of dead cells
• spatial integration	mainly from *in situ* growth	*in situ* growth and recruitment from surrounding ‘mesohabitats’
• major physical disturbances	intense grazing or water movement	increased sediment mobility or deposition
• substrate interactions	with hard substrate or macrophyte	with sediment particles and interstial water
• oxygen and light regime	more aerobic and euphotic environment	adaptations to anaerobic and low-light conditions
• spatial heterogeneity, patchiness	higher?	lower?
• phytoplankton contribution	usually small	can be substantial
• abundance of ‘opportunistic’ taxa	mostly low to moderate	frequently high

Data are from 141 water bodies. Most are small (0.02-74 ha) and unstratified ($Z_{max.}$ 0.5-18 m). Alkalinity ranges from 0.1 to 5.2 meq l^{-1}, pH from 6.5 to 9.3, EC from 190 to 3520 µS cm^{-1}, chl *a* from < 3 to 310 µg l^{-1} and TP from < 70 to 2.890 µg l^{-1}. Unless otherwise indicated, values for water-column variables are medians of 3-6 measurements (May-November). Diatom counts of 500 valves; 0.02 % attributed to additional taxa.

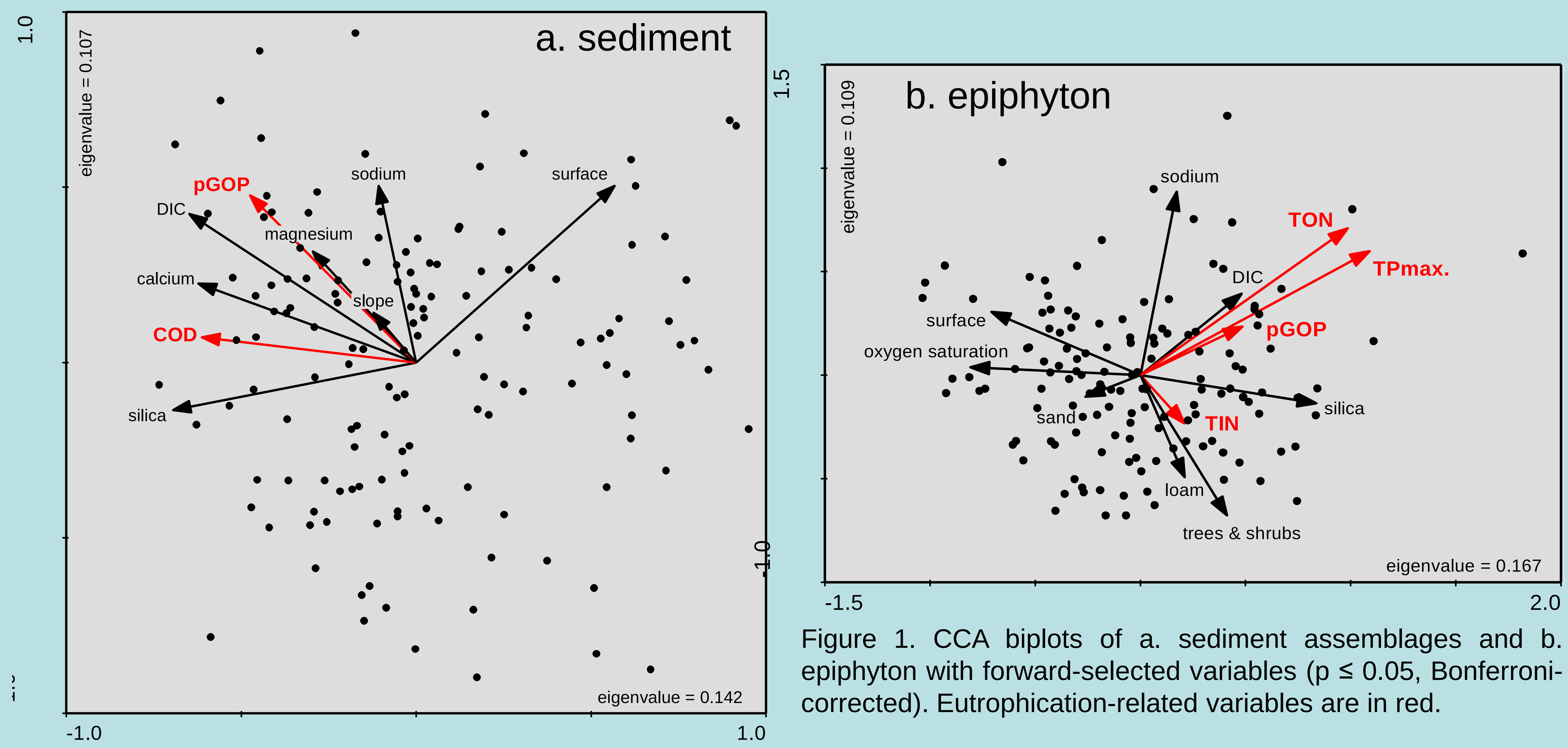


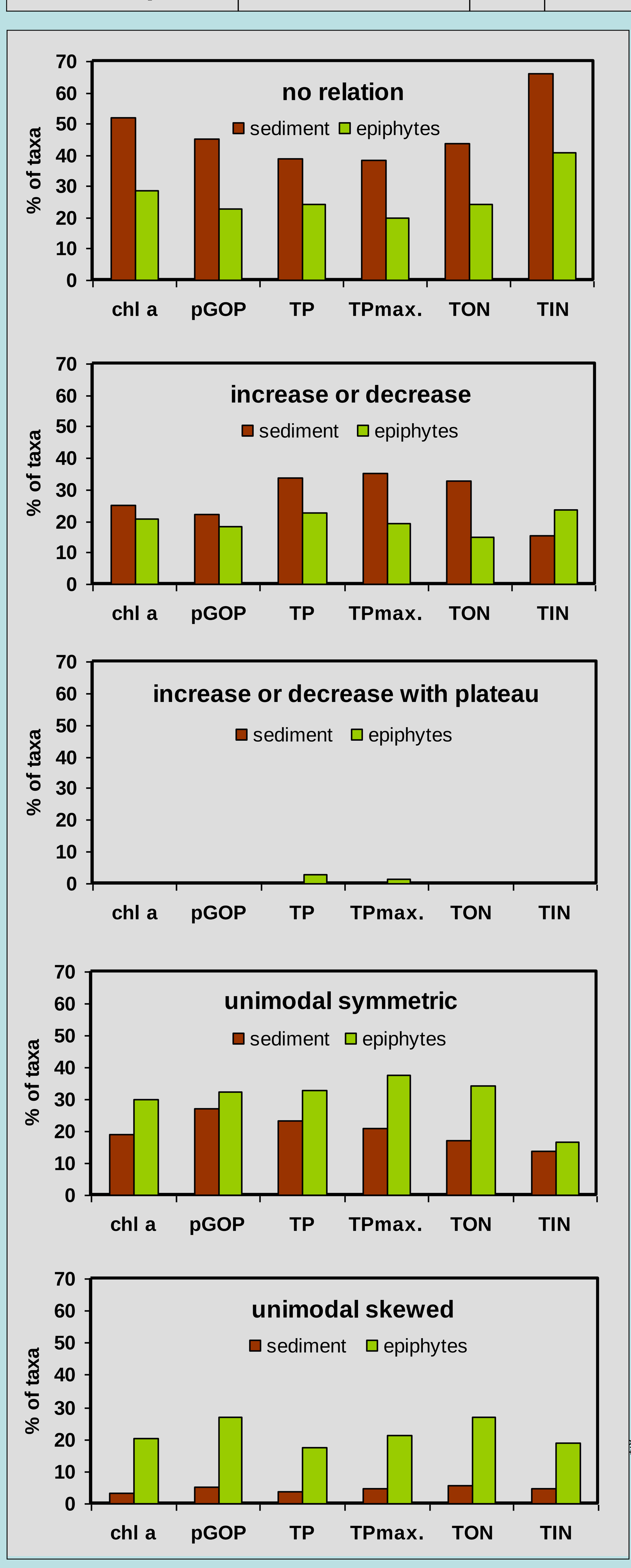
Figure 1. CCA biplots of a. sediment assemblages and b. epiphyton with forward-selected variables (p ≤ 0.05, Bonferroni-corrected). Eutrophication-related variables are in red.

Table 2. Results of CCAs constrained to eutrophication-related variables (transformed; with single variables, significance is for the constrained axis only).

	sediment assemblages			epiphytic assemblages		
	% species data explained	F	*p*	% species data explained	F	*p*
TP	2.9	3.6	0.002	3.0	4.2	0.001
TPmax.	2.6	3.7	0.002	3.3	4.6	0.001
TON	2.9	4.2	0.001	3.1	4.3	0.001
TIN	0.9	1.3	0.054	1.2	1.6	0.005
TN	2.1	2.9	0.001	1.9	2.6	0.001
pGOP	2.9	4.2	0.001	2.1	3.0	0.001
chl *a*	2.6	3.6	0.002	1.9	2.7	0.001
TP+TON+pGOP	7.2	3.5	0.001	7.2	3.5	0.001

Trophic variables: which ones and how important are they?

Potential gross oxygen production (pGOP), a measure for phytoplankton productivity, and *chemical oxygen demand* (COD) are the variables associated with trophic status showing the strongest links to sediment assemblage composition (Figure 1a). Epiphytic diatoms can be related to *maximum total phosphorus* (TPmax.), *total organic nitrogen* (TON), *pGOP* and *total inorganic nitrogen* (TIN) (Figure 1b). The marginal effects of TP (either as median or maximum values), TON (substituting COD for sediment assemblages; r = 0.83) and pGOP are comparable, although quite small (Table 2). TON explains more variation than total nitrogen (TN) or chl *a*. The combined effect of TP, pGOP and TON is the same for both assemblage types, but together these variables still account for only c. 1/14th of the variation in species composition.



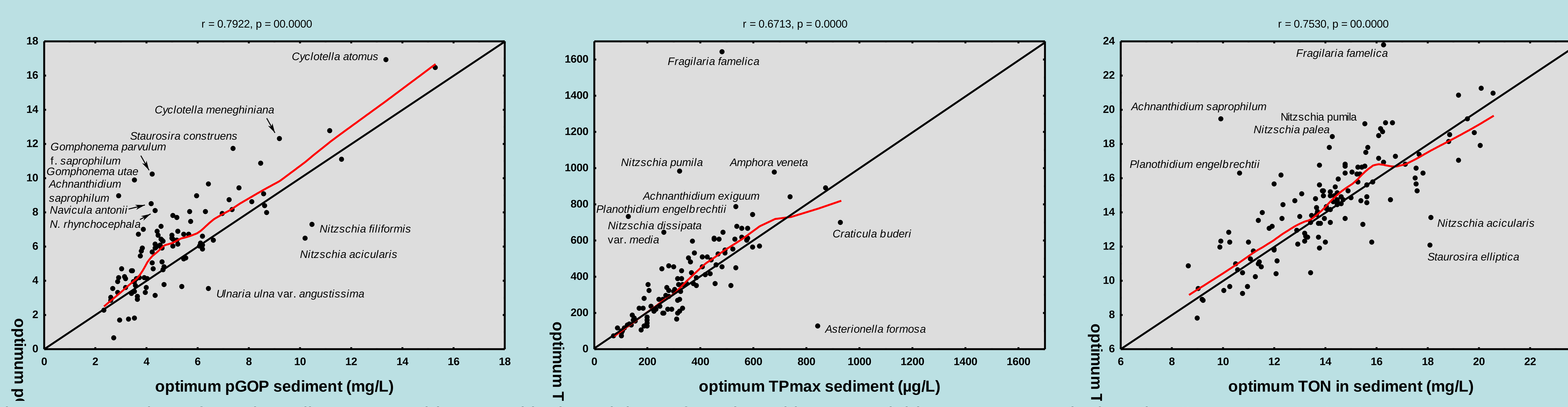


Figure 3. WA-optima of taxa in sediment assemblages and in the epiphyton for selected impact variables. Loess smooths in red. Wilcoxon matched pairs test: pGOP p < 0.001, TPmax. p = 0.006, TON p = 0.014.

Responses at the species level

A larger proportion of taxa shows no clear response to eutrophication-related variables in sediment assemblages than in the epiphyton (Figure 2). In the sediment, more taxa increase or decrease gradually along the trophic gradient, whereas epiphytes rather tend to have unimodal distribution patterns. A taxon’s apparent optimum (as its abundance-weighted average) for a specific variable may differ considerably between both assemblage types (Figure 3); there is a tendency towards lower values in association with sediments.

Figure 2. The proportion of taxa in sediment and epiphyton assemblages showing no relation or a significant response to trophic variables (HOF analyses of taxa with at least 10 occurences; p ≤ 0.05).

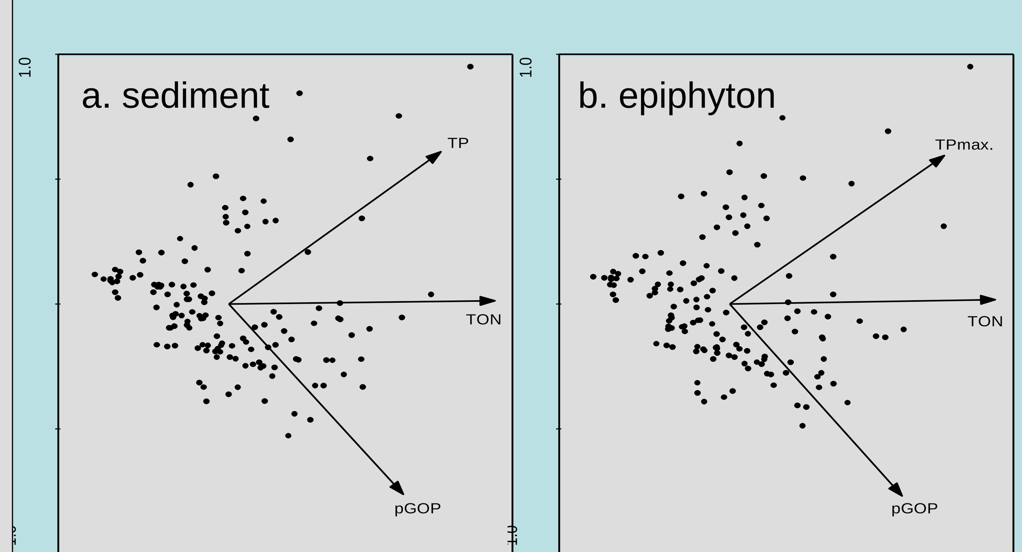


Figure 4. PCA biplots of selected impact variables and diatom samples from a. sediments and b. epiphyton.

Table 3. Scores of selected impact variables on the principal PCA axis and the variance explained by axis 1.

	axis 1 score	
	sediment	epiphyton
TP	0.75	-
TPmax.	-	0.76
TON	0.94	0.94
pGOP	0.62	0.61
% var.	60.6	60.6

Assessing eutrophication impact from diatoms

Using indicator taxa. The first axis of a PCA with TP or TPmax., TON and pGOP represents a compound impact gradient (Figure 4, Table 3). Taxa can be ordered along this gradient by means of detrended CCA, constrained to the PCA scores, identifying the most reliable indicators (Figure 5). Impact can be inferred from their relative abundance.

Using calibration models. Assessing assemblage response to relevant proxies requires a robust relation. Useful models were developed for pGOP from sediment assemblages and for TPmax. using epiphytes (Figure 6). Model characteristics and assemblage composition allow to assess the significance of inferred changes through time.

Figure 5. Species plots of DCCA analyses for sediment and epiphyton assemblages constrained to the summary PCA score for eutrophication. Only taxa with at least 10 occurrences, a non-flat response and a weight of at least 5 % are shown.

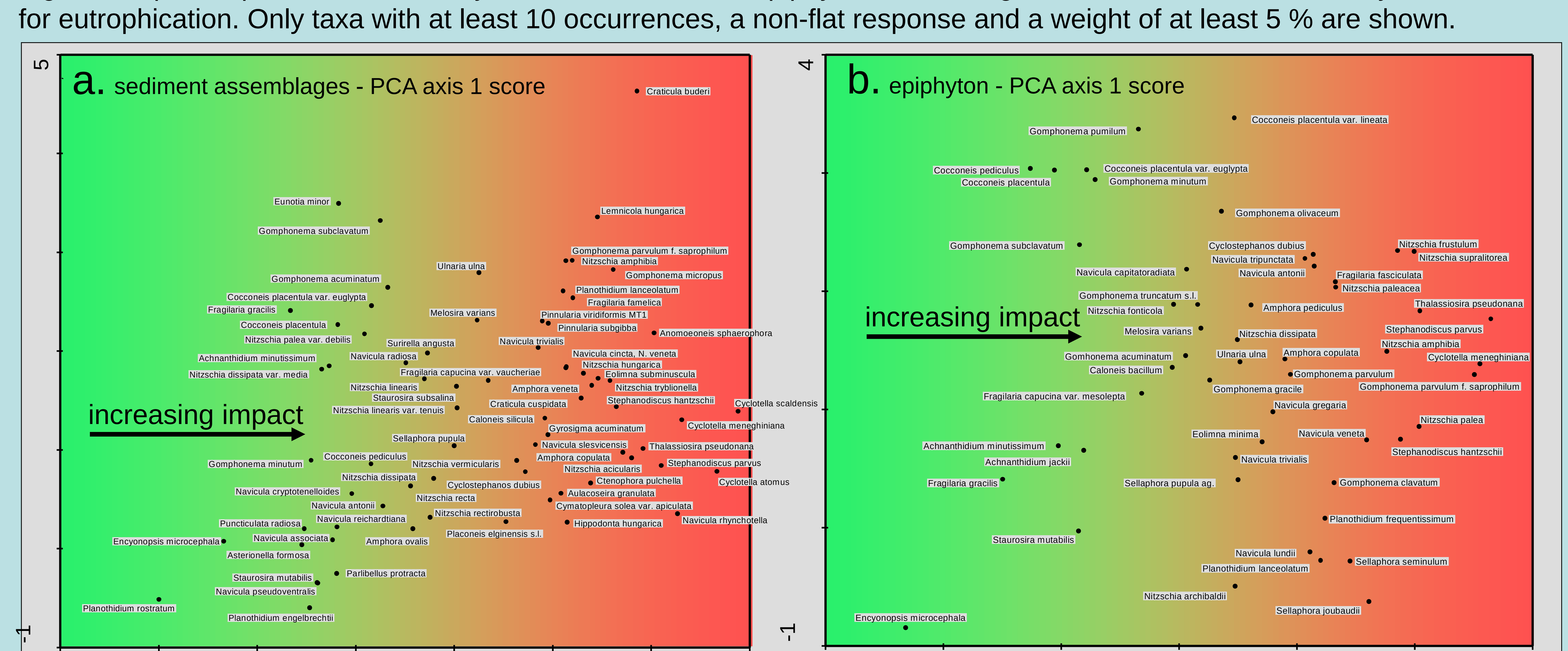


Figure 6. Calibration models for eutrophication variables: a. sediment assemblages, b. epiphyton.