Stomach Content Analyses of *Simulium perflavum* Roubaud 1906 (Diptera: Simuliidae) Larvae from Streams in Central Amazônia, Brazil

Yamile B Alencar/+, Thelma A Veiga Ludwig*, Climéia C Soares, Neusa Hamada**

Coordenação de Pesquisas em Entomologia **Coordenação de Pesquisas em Biologia de Água Doce, Instituto Nacional de Pesquisas da Amazônia, Caixa Postal 478, 69011-970 Manaus, AM, Brasil *Laboratório de Ficologia, Departamento de Botânica, Universidade Federal do Paraná, Curitiba, PR, Brasil

Stomach contents of Simulium perflavum *Roubaud larvae were analyzed and compared with plankton and periphyton collected in five streams, in Central Amazonia (Manaus and Presidente Figueiredo counties), in Sep./Oct.1996 (dry season) and Feb./Mar. 1997 (rainy season). A total of 1,400 last-instar larvae were dissected; the stomach contents were analyzed using different methods: fresh and after oxidation. A total of 87 taxa (algae, diatoms and rotifers) were found in the stomach contents. In each stream, qualitative samples of plankton and periphyton were collected; these were mounted between slides and cover slips. A total of 94 taxa of plankton and 54 taxa of periphyton were collected. One species of Rotifera was present in the stomach contents, plankton and periphyton. Cluster analysis based on species composition of the organisms present in the stomach contents grouped the streams into two major groups, each belonging to a different drainage area. Correlations based on presence/absence of species of microalgae in the stomach contents, plankton and periphyton indicated significant associations (p<0.05) between stomach contents and plankton and between plankton and periphyton (z test); the Sorensen coefficient and cluster analysis corroborate the same associations.*

Key words: aquatic insects - black fly - diatoms - microalgae - stomach contents - Amazônia - Brazil

Black fly larvae usually are abundant in running-water ecosystems and very important in the food chain because they process fine particulate organic matter making it available for other insects and fishes (predators). The size of particles ingested by black fly larvae is a factor influencing the effects of particulate insecticides on these larvae and on other organisms that live in the same habitat (Lacey & Lacey 1983). Knowing the minimum dimensions of particles ingested by the larvae can help in choosing the minimum dimensions of insecticides and microorganisms to be maintained in suspension in the water (Lozovei 1989).

Few studies of black fly larval feeding have been done in Brazil. Lozovei (1989) observed 118 species of diatoms (Bacillariophyta) in the larval stomach contents of three species of black fly, Dellome Filho (1989) reported 50 genera of Bacillariophyta, Chlorophyta, Cyanophyta and Euglenophyta in the stomach contents of *Simulium incrustatum* Lutz, 1910 larvae. Lacey and Lacey (1983) observed that food takes 29.2 min to pass through the intestine of *Simulium fulvinotum* Cerqueira & Nunes de Mello (= *Simulium rorotaense* Floch & Abonnenc) in an Amazonian stream with a velocity of 1 m/s and 0.37 mg/l particles in suspension.

Some authors (e.g. Craig 1977, Kurtak 1979) studying the feeding behavior and the functional morphology of black fly larvae have suggested that they are grazing and filter feeding. Wotton (1980) and Fredeen (1964) observed large amounts of bacteria in the stomach contents of black fly larvae.

This is the first study on the stomach contents of black fly larvae in the northern region of Brazil. The study identifies the organisms in the stomach contents of *S. perflavum* larvae and compares them with the plankton and the periphyton present in the streams. The five streams are compared with each other based on stomach contents of black fly larvae.

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+Fellowship from CNPq (139761/96-9) and corresponding author. Fax: +55-92-643.3195
E-mail: yamile@inpa.gov.br
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MATERIALS AND METHODS

This study was carried out in five streams in Central Amazônia, three of which were located in the area of the BR-174 highway, Manaus county and two in Presidente Figueiredo county (2°39'S 60°2'W; 2°23'S, 59°59'W; 2°29'S, 60°1'W; 2°2'S, 59°59'W; 2°2'S, 59°52'W, respectively) (Fig. 1). These streams have many characteristics in common: all flow through yellow latosol soil and are located in areas that have been disturbed due to the opening of highways.

In the Manaus area the year can be divided into two seasons: a rainy season from Dec. to May (Mar. being the rainiest month with an average of 281 mm), and a dry season from Jun. to Nov. (Aug. being the month with the lowest precipitation, with an average of 39 mm) (Araújo 1970). The samples were taken during two months of the dry season (Sep./Oct. 1996) and two months of the rainy season (Feb./Mar. 1997). In each stream, measurements were made of water conductivity (Cole-Parmer conductivimeter), temperature (mercury thermometer) and pH (Cole-Parmer pH Testr 2).

Black fly stomach contents were analyzed using two different techniques. Seventy larvae from each stream were dissected monthly during the study period; from this total 20 larvae were maintained alive on ice, transported to the laboratory and dissected on the same day, two slides were mounted with the larval black fly stomach contents using glycerine jelly (Lozovei & Luz 1976), each slide contained the stomach contents of 10 larvae. The remaining 50 larvae were preserved in Carnoy (3 parts absolute ethanol: 1 part glacial acetic acid) or 80% ethanol for later dissection and treatment using the slow-oxidation technique (Moreira Filho & Valente Moreira 1981); permanent slides were mounted using Hyrax (I.R = 1.7) as the mounting medium.

Permanent and semi-permanent slides were examined under a Zeiss compound microscope. The organisms present on these slides were counted over the whole field of the coverslip at 40x and 100x.

Plankton were collected using a net with 20 µm mesh during 30 min. The samples were placed in 40 ml vials and preserved in Transeau solution (1:1 proportion). Periphyton were collected in the streams from submersed leaves used as substrate by larvae. The material was removed with a brush, placed in 120 ml plastic vials and preserved in Transeau solution.

Identifications of Cyanophyta, Euglenophyta, Dinophyta and Chlorophyta were based on Bourrely (1968, 1970, 1972). The identifications of Bacillariophyta (diatoms) were based on Husted (1930), Krammer and Lange-Bertalot (1985, 1986,

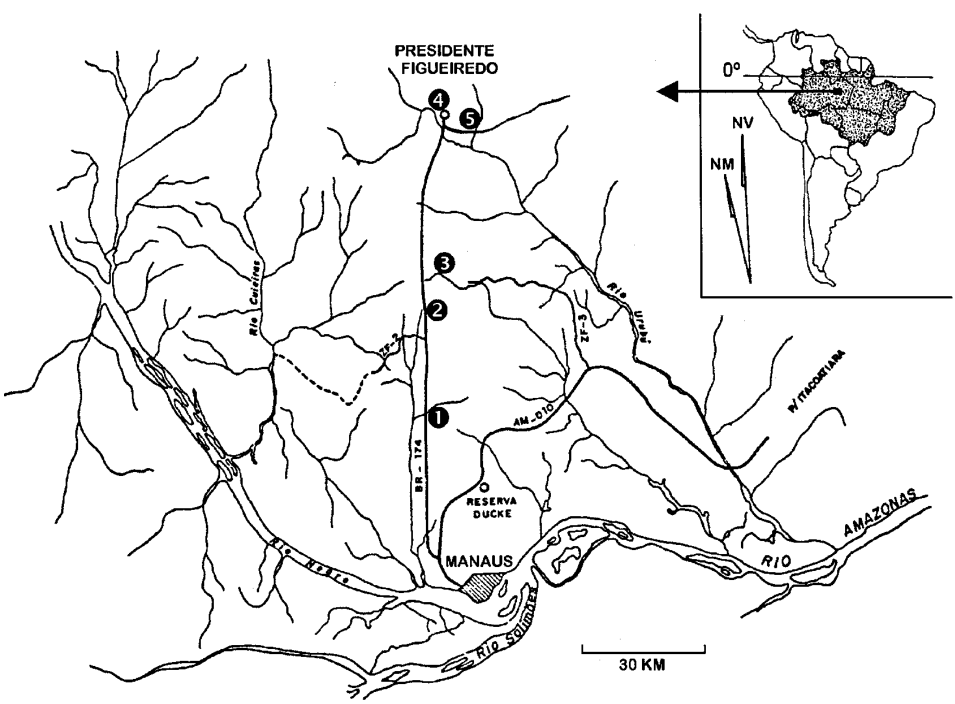


Fig. 1: collection places in Manaus and Presidente Figueiredo counties, Amazonas, Brazil. 1: Ibama stream; 2: Bueiro stream; 3: ZF3 stream; 4: Cemitério stream; 5: Escada stream

1988, 1991a,b), Kobayasi and Nagumo (1988), and Cox (1996).

Vouchers of *S. perflavum* (larval carcasses) were deposited in the invertebrate collection of the Instituto Nacional de Pesquisas da Amazônia (INPA). Samples of plankton and periphyton and the permanent and semi-permanent slides with stomach contents were deposited in the INPA and the Universidade Federal do Paraná (UFPR).

Similarity patterns based on species present in the three levels (i.e. plankton, periphyton and stomach contents of *S. perflavum* larvae) were verified using the Sorensen coefficient based on presence/absence data. Sorensen coefficient = 2A/2A + B + C, where A = number of species common to the two levels, B = number of species exclusive to level 1, and C = number of species exclusive to level 2. The significance of correlation among the three levels was tested using the z statistic, based on nominal data (Zar 1996). Similarity dendrograms from the similarity matrix with the Sorensen coefficient (binary data) were derived using UPGMA methods (non-balanced means) based on Pielou (1984).

RESULTS AND DISCUSSION

The streams in the study area had pH values of 4.4 to 5.3, conductivities of 9.4 to 12.6S/cm^2 and temperatures of 25° to 29°C, these being representative values of streams in the study, which are normally acidic and poor in mineral salts (Sioli 1965).

S. perflavum larvae feed on diatoms, algae and other organisms present in the plankton and periphyton (Figs 2-72). In the stomach-content analyses (permanent slides), during the dry and rainy seasons 40 species of diatoms were observed; the frequencies of occurrence are presented in Table I.

The Bueiro, ZF3 and Cemitério streams had *Peronia* sp. as the most frequent diatom species in the dry season (35%, 22% and 23%, respectively). In the rainy season, the most frequent diatom species were different in these three streams; in the Bueiro stream the most frequent species was *Frustulia crassinervia* (24%), in the ZF3 stream it was *Eunotia gibbosa* (66%) and in the Cemitério stream it was *Actinella brasiliensis* and *Eunotia conversa* (18% and 17.9%, respectively). The Escada stream had *E. gibbosa* as the most frequent diatom species in the dry and rainy seasons (21% and 14%, respectively). The Ibama stream had *F. crassinervia* as the most frequent species in the dry season (24%) and *E. bilunaris* in the rainy season (44%).

Species of *Actinella* and *Eunotia* are indicators of acidic waters (Patrick & Reimer 1966). By the frequent presence of these two genera in the stomach contents of *S. perflavum* larvae we can characterize the breeding place of this black fly species as being tropical, oligotrophic, acidic waters.

The semi-permanent slides with the stomach contents of *S. perflavum* larvae had a predominance of non-silicose algae. A total of 42 species of non-silicose microalgae were identified, six species of diatoms and one species of Rotifera, *Lecane* (*Monostyla*) *quadridentata* Ehrenberg (Table II). *Oedogonium* sp. was the most frequent species in the Bueiro stream in the dry and rainy seasons (70.8% and 74.3%, respectively). In the ZF3 stream, the most frequent species in the dry and rainy seasons was *Microspora* sp. (44.6% and 63.1%, respectively). In the Cemitério stream, *Pleurotaenium minutum* Ralfs Delp. was the most frequent species in the dry season (34.6%) and *Pleurotaenium* sp. in the rainy season (27.8%). In the Escada stream, *Microspora* sp. was the most frequent species (47%) in the dry season and in the rainy season *Closterium* sp. was the most frequent (28.6%). In the Ibama stream, *Hyalotheca* sp. was the most frequent species in the dry and rainy season (53.5% and 37.6%, respectively).

The dimensions of diatoms observed in the stomach contents of *S. perflavum* in the five studied streams were between 67.8 and 133.57 µm for *E. serra* Ehrenberg and *Stenopterobia curvula* (W. Smith) Krammer, respectively. For the other divisions of microalgae, the sizes range from 150 to 608 µm (*Closterium* sp., *Mougeotia* sp.) and from 65 to 1000 µm (*Oedogonium* sp.) (Burton 1973).

Depending on the classification of the phytoplankton, the size can vary from 2 to 500 µm. Kurtak (1978) conducted detailed studies on the size and proportion of the ingested particles of black fly larvae and observed a predominance of large particles (150 µm) compared to the smaller ones (5-10 µm).

A great variety of food items is reported in black fly larval diets: fungal spores and mycelia, silt, detritus, Rotifera, several species of algae and diatoms (Peterson 1956, Kuznetsov 1981). The diatoms may be important food items because they are reported to be the main components of autoctonous periphyton and are constantly removed from the substrate by the water current, becoming abundant in the plankton (Dudley et al. 1986, Thompson 1987).

In this study, the qualitative analysis of the plankton found 94 infrageneric taxa: 53 Chlorophyta, 29 Bacillariophyta, 7 Cyanophyta, 2 Euglenophyta, 2 Rhodophyta and 1 Dinophyta (Table III). In the qualitative periphyton samples taken during the dry and rainy seasons we found 33 species of microalgae, 21 species of diatoms and one species of Rotifera, *L. quadridentata* (Table III).

The similarity patterns based on qualitative data on items in the larval black fly stomach contents, plankton and periphyton were verified with the Sorensen coefficient. The results indicated 58% similarity between organisms present in the stomach contents and plankton in the streams, with 41.4% of the species in common. The similarity between the periphyton and the larval stomach contents was 54%, with 36.8% of the species in common. The Sorensen coefficient also indi-

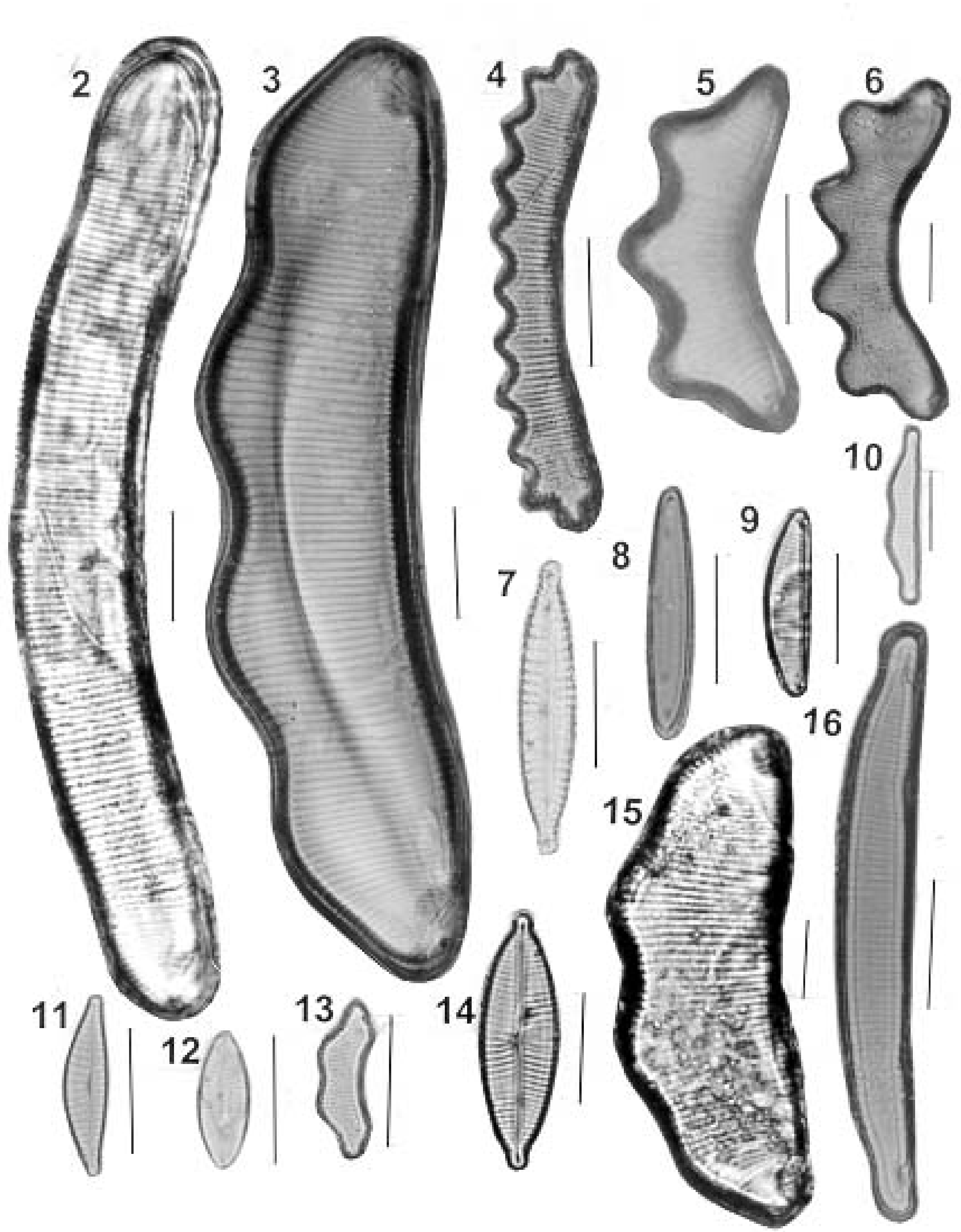


Fig. 2: *Eunotia maior*. Fig. 3: *E. zygodon*. Fig. 4: *E. serra*. Fig. 5: *E. triggiba*. Fig. 6: *E. subrobusta*. Fig. 7: *Cymbella difficilis*. Fig. 8: *Peronia brasiliensis*. Fig. 9: *E. minor*. Fig. 10: *E. bidentula*. Fig. 11: *C. minuta*. Fig. 12: *Achnanthes* sp. Fig. 13: *E. gibbosa*. Fig. 14: *Cymbella* sp. Fig. 15: *E. zygodon*. Fig. 16: *E. sudetica*. Bar = 10 µm

cated a 63% similarity among organisms in the plankton and periphyton with 45.6% of the species in common.

The hierarchical grouping analyses based on presence and absence with the Sorensen coefficient resulted in 72% similarity between food items in the larval stomach contents and plankton in the streams, and 67% similarity between the larval stomach contents and the periphyton (Fig. 73). Therefore, the stomach content items were more

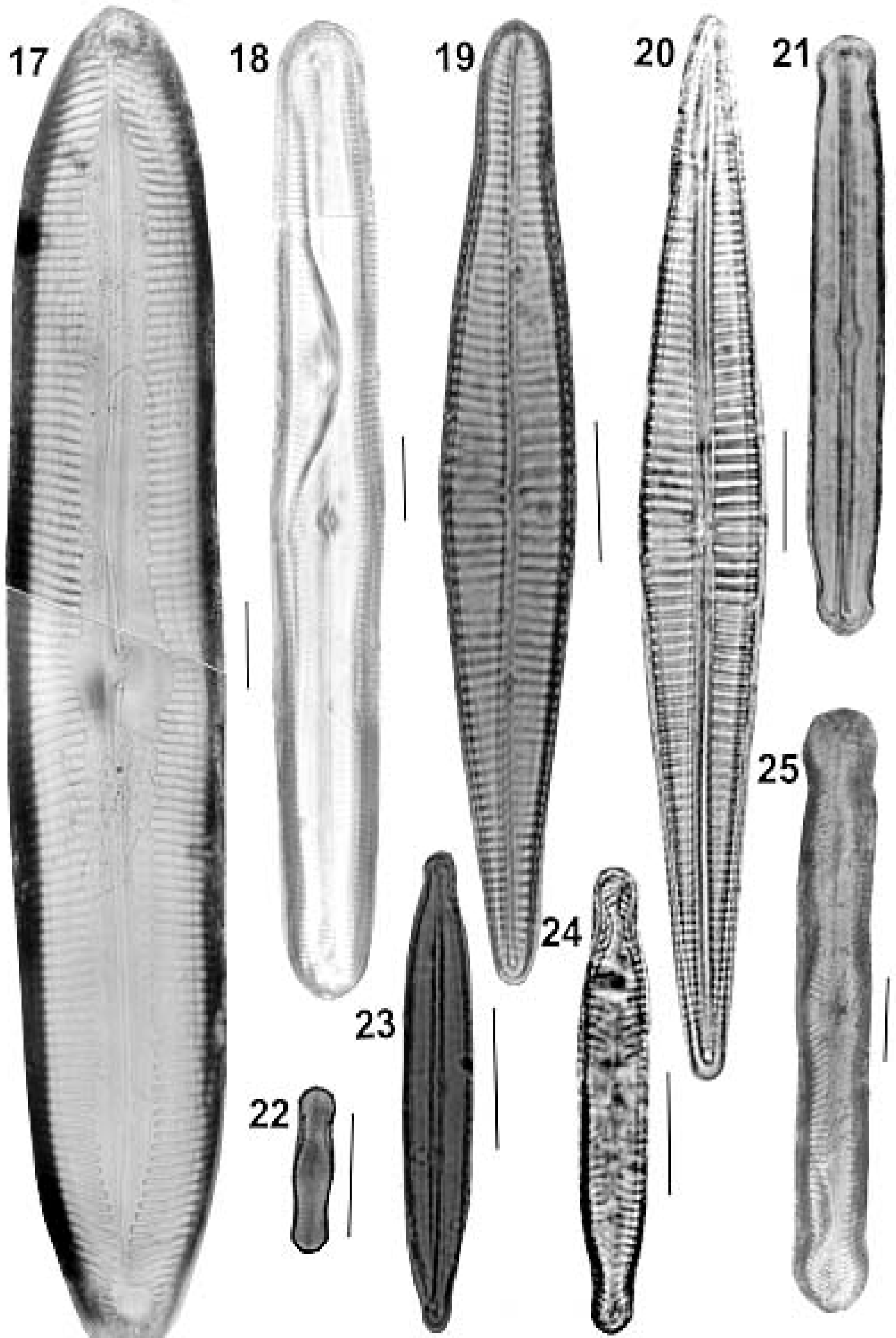


Fig. 17: *Pinnularia streptoraphe*. Fig. 18: *P. maior*. Fig. 19: *Gomphonema* sp. Fig. 20: *G. gracile*. Fig. 21: *Navicula subtilissima*. Fig. 22: *Navicula* sp. Fig. 23: *N. parasubtilissima*. Fig. 24: *P. subcapitata*. Fig. 25: *Pinnularia* sp. Bar = 10 µm

TABLE I

Frequency of diatoms (permanent slides) in the stomach contents of *Simulium perflavum* (Diptera: Simuliidae) larvae in five streams in Central Amazônia, during the dry (Sep./Oct. 1996) and rainy seasons (Feb./Mar. 1997)

Diatoms	Bueiro		ZF3		Cemitério		Escada		Ibama	
	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy
Achnanthes sp.	51	40	15	24	40	4	14	37	54	163
Actinella brasiliensis Grun.	127	145	122	151	180	296	113	309	287	83
Actinella peronioides Hustedt	168	190	77	152	141	2	12	1	226	104
Actinella punctata Lewis	16	57	5	—	8	—	—	—	15	—
Brachysira kuntzei (Reichelt) Metzeltin & Lange-Bertalot	28	—	21	150	90	—	16	—	19	6
Brachysira serians (Bréb.) Round & Mann var. *brachysira* (Hus.) Cox.	122	178	55	4	185	1	54	71	202	115
Brachysira serians (Brébisson) Round & Mann	156	177	54	209	232	198	405	1030	309	192
Brachysira vitrea (Grun.) Ross	285	231	182	2	398	5	802	142	336	27
Cyclotella sp.	—	3	—	2	—	—	—	—	—	1
Cymbella difficilis Krasske	15	3	5	261	43	3	3,085	1,589	38	38
Cymbella minuta Hilse	42	56	38	136	130	9	402	601	74	35
Cymbella sp.	—	1	1	—	—	—	1	3	1	1
Eunotia bidentula W. Smith	30	41	28	76	32	3	17	40	61	26
Eunotia bilunaris (Ehrenberg) Mills	175	574	127	1148	392	48	648	203	2,121	9,410
Eunotia conversa Hustedt	301	350	388	230	525	313	376	768	1,254	251
Eunotia flexuosa (Brébisson) Kützing	1,548	1,870	1,200	1,584	1,769	144	1,401	2,167	1,016	300
Eunotia gibbosa Grunow	220	251	294	19,614	1315	2	3,889	2,332	823	274
Eunotia maior (W. Sm.) Rabh.	—	—	1	—	—	—	—	—	—	—-
Eunotia minor (Kützing) Grunow	1	—	—	—	—	—	—	—	—	—
Eunotia serra Ehrenberg	2	—	4	14	7	—	18	33	4	2
Eunotia sudetica O. Müller	106	57	125	224	209	38	390	37	70	21
Eunotia trigibba Hustedt	2	—	5	32	5	2	9	6	7	4
Eunotia zygodon Ehrenberg	1	3	2	38	35	—	266	345	3	4
Fragilaria javanica Hustedt	7	—	8	—	5	1	30	70	—	—
Frustulia crassinervia (Bréb.) Lange-Bertalot & Krammer	1,555	2,280	939	750	1,632	188	718	1,242	3,116	3,077
Frustulia rhomboides (Ehrenberg) De Toni	53	81	63	574	383	87	1,102	1679	471	161
Gomphonema gracile Ehrenberg	104	62	325	1920	580	1	482	316	253	154
Gomphonema sp. Ehrenberg	36	8	48	47	15	—	—	25	—	29
Navicula cryptocephala Kützing	497	505	321	127	1,312	113	420	941	678	311
Navicula parasubitilissima Kobayasi & Nagumo	1	—	—	—	—	—	—	—	—	—
Navicula subtilissima Cleve	112	59	67	21	126	56	140	153	131	48
Peronia brasiliensis Hustedt	3,156	2,124	1,552	302	2,865	62	920	1,203	1,095	170
Pinnularia maior (Kützing) Rabenhorst	10	12	21	63	41	21	56	12	50	2
Pinnularia sp.	15	32	17	20	27	55	28	74	7	36
Pinnularia streptoraphe Cleve	85	16	47	76	152	1	13	18	90	7
Pinnularia subcapitata Gregory	—	—	1	—	—	—	—	—	—	—
Stenopterobia curvula (W. Smith) Krammer	1	18	—	132	37	4	27	141	81	53
Stenopterobia delicatissima (Lewis) Van Heurck	30	11	44	48	28	—	10	8	6	5
Surirella robusta Ehrenberg	6	9	—	33	5	—	39	15	5	5
Tabellaria sp.	—	9	1	—	14	—	—	1	2	—
Total	9,064	9,453	6,203	28,164	12,958	1,657	15,903	15,612	12,905	15,115

—: absence

TABLE II

Frequency of organisms (semi-permanent slides) in the stomach contents of *Simulium perflavum* (Diptera: Simuliidae) larvae in five streams in Central Amazônia, in the dry (Sept./Oct. 1996) and rainy seasons (Feb./ Mar. 1997)

Organisms observed	Bueiro		ZF3		Cemitério		Escada		Ibama	
	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy
Actinotaenium curcubita (Bréb.) Teiling	—	1	—	—	—	—	—	—	—	—
Actinotaenium globosum (Bulnheim) Teiling	—	—	—	—	1	1	1	—	1	3
Actinotaenium sp.	—	—	—	—	—	—	2	—	—	—
Actinotaenium wollei Kütz	—	—	—	—	—	—	1	—	1	—-
Anabaena sp.	—	—	—	—	1	—	—	—	—	—
Bambusina brebissonii Küetz	1	1	91	125	—	—	—	—	5	12
Cosmarium sp.	—	—	—	—	—	—	—	—	1	1
Closterium sp.	2	3	44	41	6	4	112	22	74	26
Closterium dianai Ehrenberg	—	—	3	1	—	—	32	9	2	—
Closterium regulare Brébisson	—	—	—	1	—	1	1	—	—	—
Closterium pronum Brébisson	—	—	—	—	—	—	1	1	2	—
Closterium navicula (Bréb.) Lütkemüller	—	—	—	—	—	—	2	1	1	—
Closterium subulatum (Kütz) Bréb.	—	—	—	—	—	—	—	7	4	—
Desmidium elegans (Racib.) Grönblad.	—	—	1	3	—	—	—	—	—	—
Desmidium sp.	—	—	—	—	—	—	—	—	—	2
Desmidium cylindricum Greville	—	—	—	—	—	—	—	—	1	—
Euastrum sinuosum Lenorm	—	1	—	—	—	—	—	1	—	1
Euastrum sp.	1	—	—	—	—	—	—	—	—	—
Euglena acus Ehrenberg	1	—	1	—	—	—	—	—	1	—
Eunotia flexuosa (Brébisson) Kütz	—	—	1	—	—	—	—	—	—	—
Eunotia sp.	—	—	1	—	3	—	1	—	—	—
Frustulia rhomboides (Ehrenberg) De Toni	1	—	—	—	—	—	1	5	1	—
Hyalotheca dissiliens (Smith) Bréb.	1	—	—	—	—	—	—	—	787	190
Hyalotheca sp.	2	7	—	1	1	—	1	2	1,440	402
Microspora sp.	3	7	202	492	1	3	193	4	258	277
Micrasterias sp.	—	—	—	1	—	—	2	—	1	—
Micraterias torreyi Bailey	—	—	2	—	—	—	—	—	—	—
Micrasterias radiosa Ralfs	—	—	—	—	—	—	1	—	—	—
Micrasterias rotata (Greville) Ralfs	—	—	—	—	—	—	1	4	3	2
Mougeotia sp.	—	1	—	20	—	—	—	—	—	—
Navicula sp.	1	—	—	—	—	—	2	—	—	—
Netrium sp.	—	—	—	—	—	—	—	—	3	—
Oedogonium sp.	68	81	4	48	4	1	7	6	79	115
Oscillatoria sp.	1	—	—	1	—	—	24	2	—	—
Peridinium sp.	1	—	1	3	—	—	—	—	—	—
Pleurotaenium minutum (Ralfs) Delp.	1	2	—	—	28	—	4	7	—	2
Pleurotaenium sp.	4	3	7	8	16	5	4	1	5	2
Pleurotaenium trabecula (Ehrenberg) Nägeli	1	—	1	—	20	—	3	—	—	—
Pseudoanabaena sp.	—	—	—	2	—	—	—	—	—	—
Spondylosium sp.	—	—	—	—	—	—	—	1	—	—
Spyrogira sp.	1	1	87	8	—	—	13	4	17	35
Surirella linearis W. Smith	1	—	—	—	—	—	—	—	—	—
Surirella sp.	3	—	—	—	—	—	1	—	—	—
Tetmemorus laevis (Kützing) Ralfs	1	1	4	4	—	3	1	—	—	—
Tetmemorus granulatus (Bréb.) Ralfs	—	—	—	1	—	—	—	—	—	—
Xanthidium canadense (Joshua) Förster	—	—	—	5	—	—	—	—	—	—
Xanthidium siolii Grönblad & Croasdale	—	—	3	5	—	—	—	—	2	—
Xanthidium sp.	—	—	—	3	—	—	—	—	1	—
Rotifera										
Lecane (*Monostyla*) *quadridentata* Ehrenberg	1	—	—	1	—	—	—	—	—	—
Total	96	109	453	774	81	18	411	77	2,690	1,070

—: absence

similar to the plankton than to the periphyton. However, organisms found in the periphyton also were similar to the plankton (45.6%), possibly because the periphyton detached from the substrate and entered the water column.

Correlations based on qualitative data on items in the stomach contents, plankton and periphyton agree with the Sorensen coefficient. The correlations between the stomach content organisms and the plankton and between the plankton and the periphyton were significant (z test, $p<0.05$), while the correlation between stomach contents and periphyton was not significant (z test, $p>0.05$) (Table IV).

Based on the organisms found in the stomach contents of black fly larvae, the sampled streams can be divided into two groups with 77% similarity. The first group was composed of the Bueiro and ZF3 streams, and the second of the Cemitério, Escada and Ibama streams, being the latter group less similar to the other streams (Fig. 74).

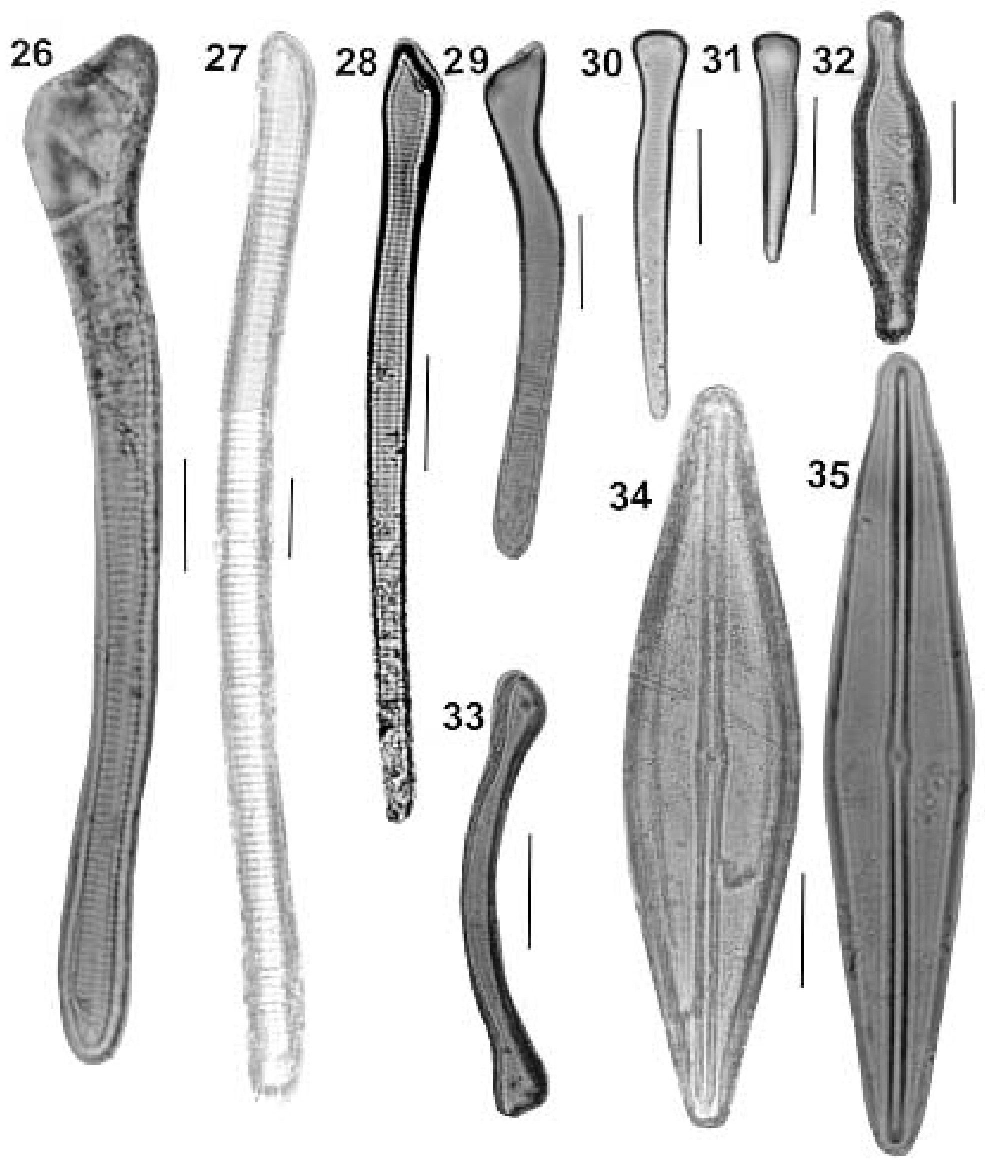
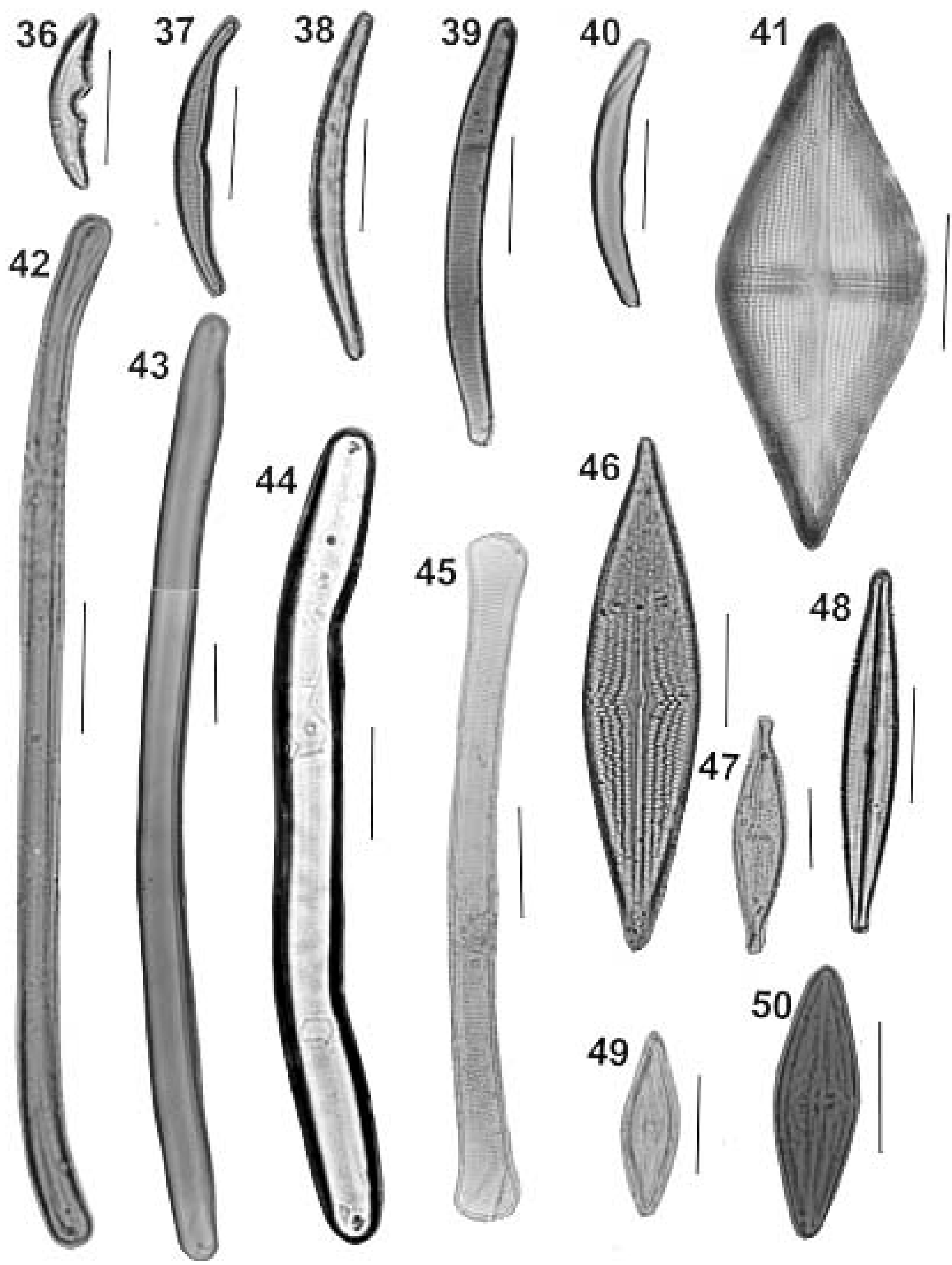


Fig. 26: *Actinella brasiliensis*. Fig. 27: *A. robusta*. Figs 28-29: *A. brasiliensis*. Figs 30-31: *A. peronioides*. Fig. 32: *Fragilaria javanica*. Fig. 33: *A. punctata*. Fig. 34: *F. rhomboides*. Fig. 35: *F. crassinervia*. Bar = 10 µm

Considering the geographical proximity of the studied streams we observed that they have geological, pedological and climatic characteristics in common. The Bueiro and Ibama streams belong to the Tarumã River Basin, ZF3 stream belong to the Rio Preto da Eva River Basin while Cemitério and Escada streams belong to the Urubu River Basin. This grouping result may be an indication that, even though the studied streams were disturbed by anthropogenic influences, they maintained characteristics of the hydrographic basins to which they belong, reflected in the composition



Figs 36-40: *Eunotia bilunaris*. Fig. 41: *Brachysira kuntzei*. Fig. 42: *E. conversa*. Figs 43-45: *E. flexuosa*. Fig. 46: *Brachysira serians*. Fig. 47: *B. vitrea*. Fig. 48: *N. cryptocephala*. Fig. 49: *B. serians* var. *brachysira*. Fig. 50: *B. serians*. Bar = 10 µm

of the phycoflora. Many workers have found that the classes of food items in the stomach contents of black fly larvae reflect, in general, the items available in the environment (e.g. Wotton 1977, Kurtak 1979).

Knowledge of black fly food items can provide important information on larval nutrition and help to clarify differences observed in population productivity of larvae in different habitats (Colbo 1982). More studies will be necessary, not only on larval feeding, but also on the ecological associations between breeding places, black fly larvae, plankton and periphyton, in order to improve our understanding of black fly bioecology.

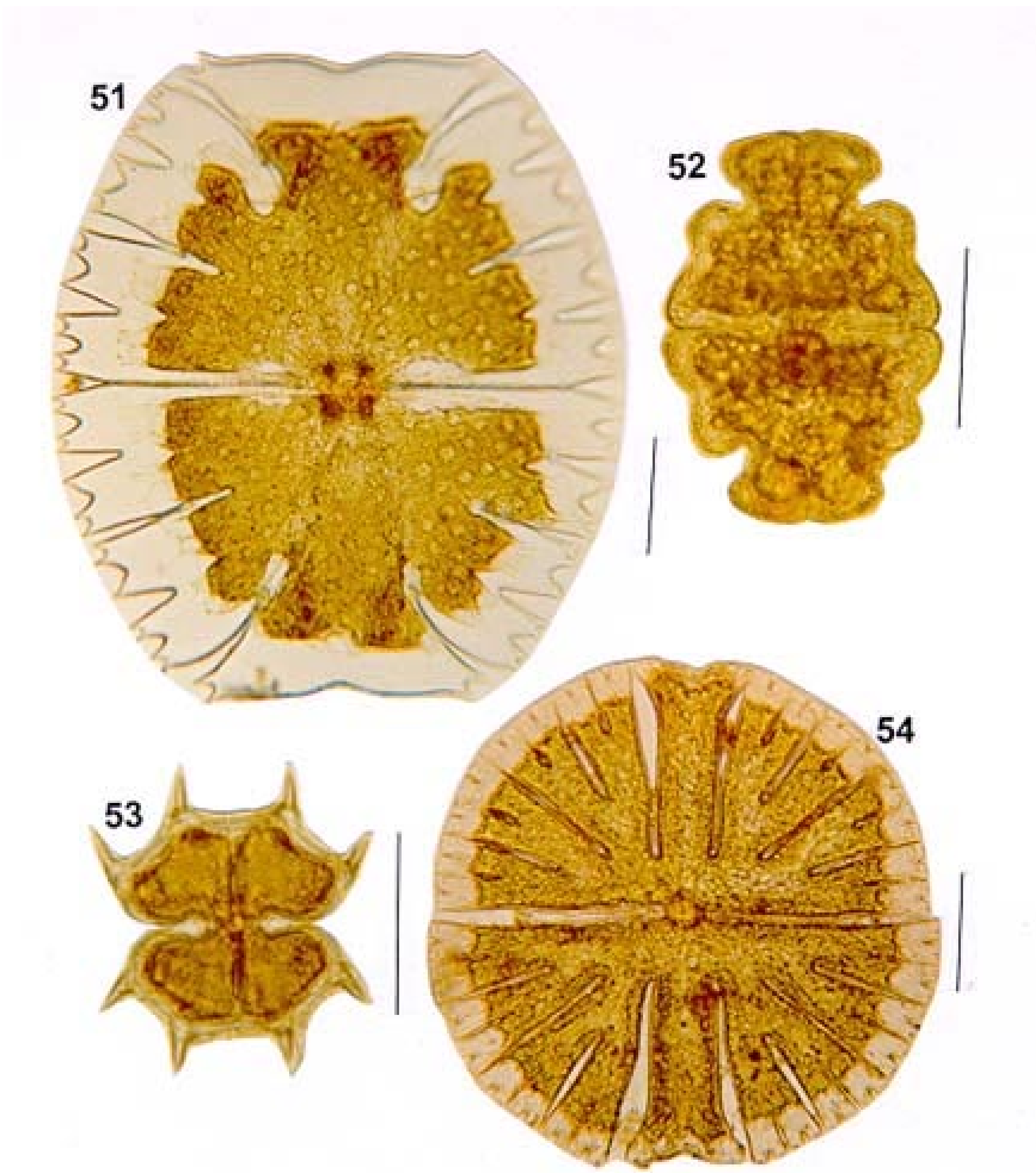


Fig. 51: *Micrasterias truncata*. Fig. 52: *Euastrum sinuosum*. Fig. 53: *Xanthidium siolii*. Fig. 54: *M. radiosa*. Bar = 50 µm

TABLE III

Presence (X) or absence (—) in the plankton and periphyton samples and stomach contents of *Simulium perflavum* (Diptera: Simuliidae) larvae collected in five streams in Central Amazonia, observed in the study period (Sep./ Oct. 1996 and Feb./Mar. 1997)

	Plankton	Periphyton	Food items
Cyanophyta			
Anabaena sp.	X	—	X
Aphanotece sp.	X	—	—
Chroococus turgidus (Kützing) Nägeli	X	—	—
Hapalosiphon sp.	X	—	—
Merismopedia sp.	X	—	—
Oscillatoria sancta (Küetzing) Gomont	X	—	—
Oscillatoria sp.	X	—	X
Pseudoanabaena sp.	—	—	X
Euglenophyta			
Euglena acus Ehrenberg	X	—	X
Trachelomonas armata (Ehrenberg) Stein	X	—	—
Bacillariophyta			
Achnanthes sp.	—	—	X
Actinella brasiliensis Grun.	—	—	X
Actinella mirabilis Grun.	X	X	—
Actinella punctata Lewis	—	—	X
Actinella peronioides Hustedt	X	X	X
Actinella guianensis Grun.	X	X	—
Brachysira serians (Brebisson) Round & Mann var. *brachysira* (Hust.) Cox.	—	—	X
Brachysira serians (Brebisson) Round & Mann	X	X	X
Brachysira vitrea (Grun.) Ross	X	X	X
Brachysira kuntzei (Reichelt) Metzeltin & Lange-Bertalot	—	—	X
Cyclotella sp.	—	—	X
Cymbella difficilis Kraske	—	—	X
Cymbella minuta Hilse	—	—	X
Cymbella sp.	—	—	X
Dinobryon sertularia Ehrenberg	X	X	—
Eunotia sp.	—	—	X
Eunotia bidentula W. Smith	—	—	X
Eunotia flexuosa (Brébisson) Kütz.	X	X	X
Eunotia gibbosa Grunov	X	—	X
Eunotia robusta Ralfs	X	—	—
Eunotia bilunaris (Ehrenberg) Mills	X	X	X
Eunotia sudetica O. Müller	X	—	X
Eunotia maior (W. Smith) Rabh.	—	—	X
Eunotia minor (Kützing) Grunow	—	—	X
Eunotia serra Ehrenberg	—	—	X
Eunotia triodon Ehrenberg	X	X	—
Eunotia trigibba Hustedt	—	—	X
Eunotia zygodon Ehrenberg	X	—	X
Eunotia conversa Hustedt	X	X	X
Fragilaria javanica Hustedt	—	—	X
Frustulia crassinervia (Bréb.) Lange-Bertalot & Krammer	—	X	X
Frustulia rhomboides (Ehrenberg) De Toni	X	X	X
Gomphonema gracile Ehrenberg	X	X	X
Gomphonema sp. Ehrenberg.	X	X	X
Aulacoseira sp.	X	—	—
Navicula sp.	X	X	X
Navicula cryptocephala Kützing	—	—	X
Navicula subtilissima Cleve	—	—	X
Navicula parasubtilissima Kobayasi & Nagumo	—	—	X
Pinnularia maior (Kützing) Rabenhout	—	X	X
Pinnularia subcapitata Gregory	—	—	X
Pinnularia streptoraphe Cleve	—	—	X
Pinnularia sp.	X	—	X
Peronia brasiliensis Hustedt	X	X	X
Stauroneis sp.	X	—	—
Stenopterobia curvula (W. Smith) Krammer	X	X	X ↓

	Plankton	Periphyton	Food items
Stenopterobia delicatissima (Lewis) Van Heurck	—	—	X
Stenopterobia intermedia Lewis	X	X	—
Surirella linearis W. Smith	X	—	X
Surirella robusta Ehrenberg	X	—	X
Surirella sp.	—	—	X
Synedra sp.	X	—	—
Fragilaria sp.	X	X	—
Tabellaria sp.	X	X	X
Rhodophyta			
Audouinella violaceae (Kütz) Hamel	X	X	—
Batrachospermum moniliferum Roth	X	—	—
Dinophyta			
Peridinium sp.	X	—	X
Chlorophyta			
Actinotaenium curcubita (Bréb.) Teiling	X	X	X
Actinotaenium globosum (Bulnheim) Teiling	X	—	X
Actinotaenium sp.	X	X	X
Actinotaenium tumidum (Gronbl.) Teiling	X	—	—
Actinotaenium wollei Kütz.	X	X	X
Bambusina brebissonii Küetz.	X	X	X
Closteriopsis sp.	X	—	—
Closterium sp.	X	X	X
Closterium dianai Ehrenberg	X	X	X
Closterium gracile Brébisson	—	X	—
Closterium kuetzingii Brébisson	X	X	—
Closterium libellula Forcke	X	X	—
Closterium macilentum Brébisson	X	X	—
Closterium navicula (Bréb.) Lütkemüller	X	—	X
Closterium pronum Brébisson	X	—	X
Closterium regulare Brébisson	X	—	X
Closterium setaceum Ehrenberg	X	X	—
Closterium subulatum (Kütz.) Bréb.	X	X	X
Closterium tumidum Johnson	—	X	—
Cosmarium incrassatum (Fritsch & Rich)	X	—	—
Cosmarium pseudoconnatum Nordstedt	X	—	—
Cosmarium siolii Forster	X	—	—
Cosmarium sp.	X	X	X
Desmidium laticeps Nordstedt	X	—	—
Desmidium cylindricum Greville	X	—	X
Desmidium grevelli (Kütz.) DeBary	X	—	—
Desmidium quadratum Nordstedt	X	—	—
Desmidium elegans (Racib.) Grönblad.	—	—	X
Desmidium sp.	X	X	X
Euastrum sp.	—	X	X
Euastrum brasiliensis Borge	—	X	—
Euastrum sinuosum Lenorm	X	—	X
Hyalotheca sp.	X	X	X
Hyalotheca dissiliens (Smith) Bréb.	—	—	X
Micrasterias borgei Krieger	X	—	—
Micrasterias radiosa Ralfs	X	X	X
Micrasterias rotata (Greville) Ralfs	X	X	X
Micrasterias siolii Scott & Croasdale	X	X	—
Micrasterias truncata (Corda) Brébisson	X	—	—
Micrasterias torreyi Bailey	—	—	X
Micrasterias sp.	—	—	X
Microspora sp.	X	X	X
Mougeotia sp.	X	X	X
Netrium sp.	—	—	X
Oedogonium sp_1.	X	X	X
Oedogonium sp_2.	X	—	—
Plerotaenium tridentulum Grönblad & Croasdale	X	—	—
Pleurotaenium coronatum (Bréb.) Rabenhorst	X	—	—
Pleurotaenium minutum (Ralfs) Delp.	X	X	X
Pleurotaenium sp.	X	X	X ↓

	Plankton	Periphyton	Food items
Pleurotaenium trabecula (Ehrenberg) Nägeli	X	—	X
Spirogyra sp.	X	X	X
Spondylosium sp.	—	—	X
Staurastrum quadrangulare Brébisson	X	—	—
Staurastrum setigerum Cleve	X	—	—
Staurastrum sp.	X	X	—
Staurodesmus sp.	X	—	—
Tetmemorus laevis (Kützing) Ralfs	X	X	X
Tetmemorus granulatus (Bréb.) Ralfs	X	—	X
Xanthidium amazonense Scott & Croasdale	X	—	—
Xanthidium siolii Grönblad & Croasdale	X	X	X
Xanthidium canadense (Joshua) Forster	X	—	X
Xanthidium sp.	—	X	X
Zygnema sp.	X	X	—
Rotifera			
Lecane (*monostyla*) *quadridentata* Ehrenberg	X	X	X

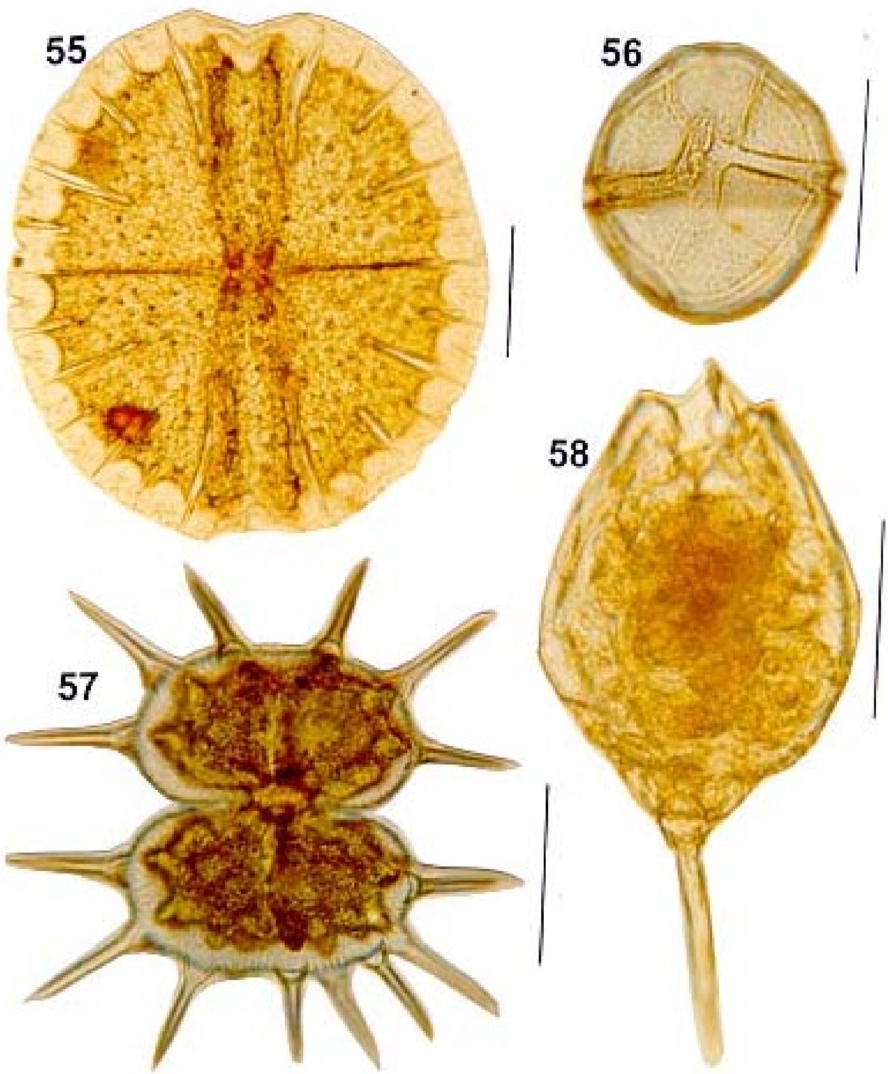


Fig. 55: *Micrasterias rotata.* Fig. 56: *Peridinium* sp. Fig. 57: *Xanthidium amazonense*. Fig. 58: *Lecane quadridentata*. Bar = 50 µm

TABLE IV

Correlation coefficient (r) and significance test (z value) between the organisms present in the stomach contents of *Simulium perflavum* (Diptera: Simuliidae) larvae, plankton and periphyton

	r	z value	n
Stomach content x plankton	- 0.34	- 3.85[a]	131
Stomach content x periphyton	0.06	0.70	131
Plankton x periphyton	0.25	2.81[a]	131

a: $p<0.05$

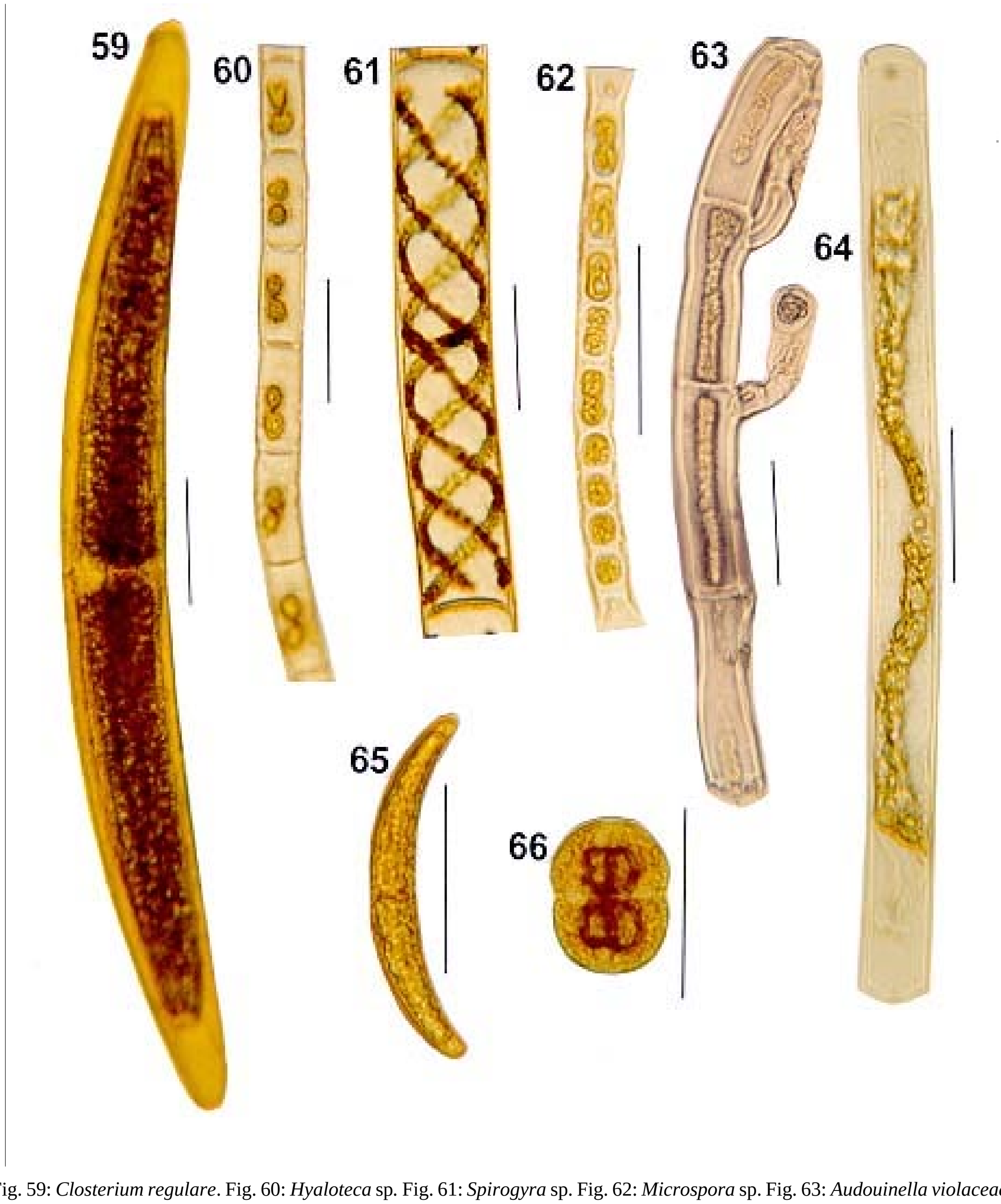


Fig. 59: *Closterium regulare*. Fig. 60: *Hyaloteca* sp. Fig. 61: *Spirogyra* sp. Fig. 62: *Microspora* sp. Fig. 63: *Audouinella violaceae*. Fig. 64: *Mougeotia* sp. Fig. 65: *Closterium* sp. Fig. 66: *Actinotaenium wollei*. Bar = 50 µm

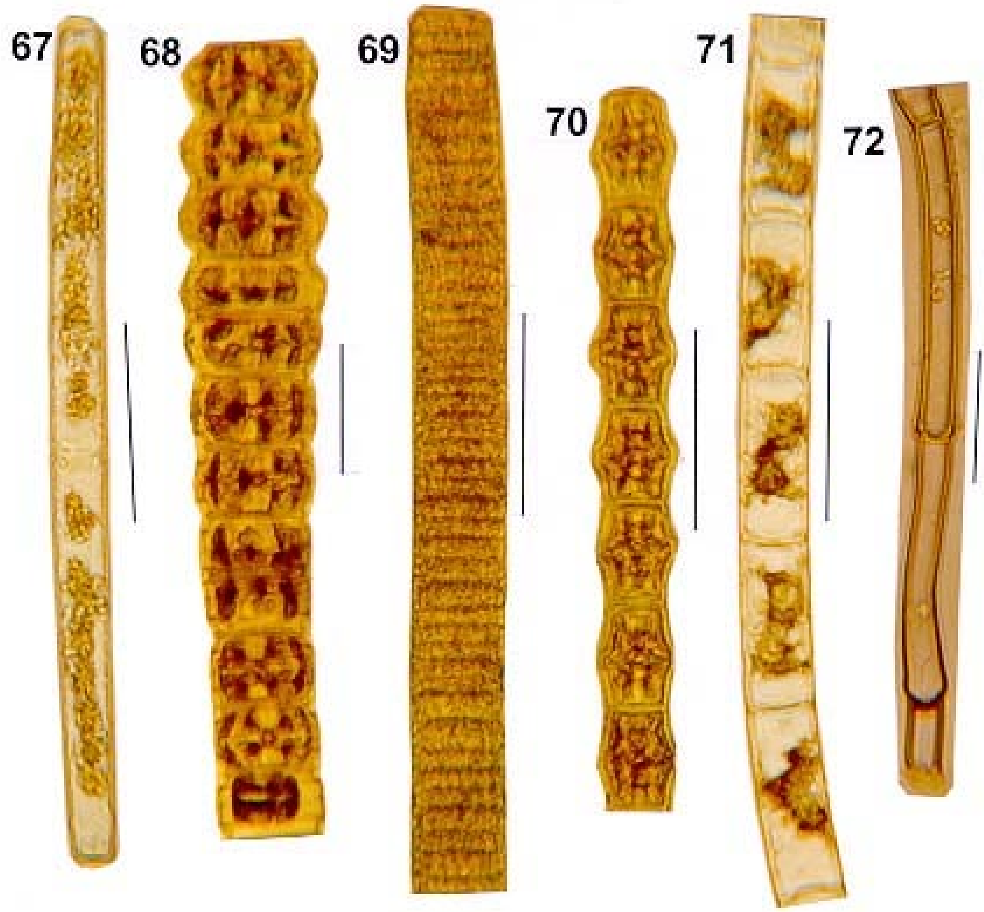


Fig. 67: *Pleurotaenium* sp. Fig. 68: *Desmidium cylindricum*. Fig. 69: *Oscillatoria* sp. Fig. 70: *Bambusina brebissonii*. Fig. 71: *Zygnema* sp. Fig. 72: *Oedogonium* sp. Bar = 50 µm

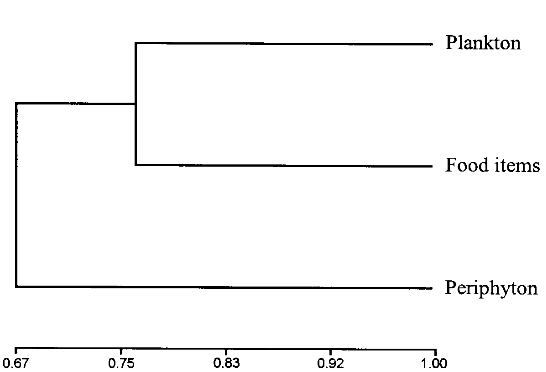


Fig. 73: similarity dendrogram between the organisms in the stomach contents of *Simulium perflavum* (Diptera: Simuliidae) larvae and the food availability in the habitat (plankton and periphyton) (Sorensen coefficient, UPGMA)

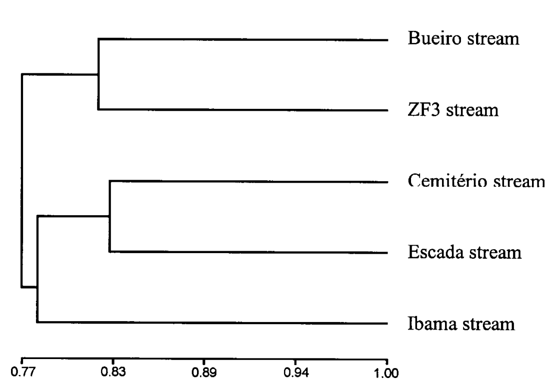


Fig. 74: similarity dendrogram between five streams in relation to the organisms in the stomach contents of *Simulium perflavum* (Diptera: Simuliidae) larvae (Sorensen coefficient, UPGMA)

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