

# EPHEMEROPTERA AND PLECOPTERA NYMPHS FROM RIFFLES IN LOW-ORDER STREAMS IN SOUTHEASTERN BRAZIL

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Aquatic insects from riffles in three low-order streams from the same catchment basin were collected in the Campos do Jordão State Park, at an altitude of ca. 1550 m. The Ephemeroptera included nymphs of the genera *Baetis*, *Baetodes*, *Camelobaetidius*, *Askola*, *Farrrodes*, *Hagenulopsis*, *Hermanella*, aff. *Hermanella*, *Massartella*, *Thraulodes*, *Leptohyphes*, *Leptohyphodes*, *Leptohyphidae* gen. and *Campylocia*. Most mayfly genera are collectors or scrapers, but two genera, *Campylocia* and *Leptohyphidae* gen., proved to be shredders, particularly of wood. The appearance of nymphs of a few genera was seasonal. The Plecoptera included nymphs of the genera *Gripopteryx*, *Paragripopteryx*, *Anacroneuria* and *Kempnyia*. The gripopterygids are scrapers, the perllids are predators. Some genera or species of both orders apparently showed preference for certain stream sizes.

## INTRODUCTION

Stream insect communities have historically received little attention in Brazil. Two pioneering studies are those of LUTZ (1930) concerning the fauna of rapids, and of SCHUBART (1946) concerning the fauna of Rio Camanducaia in the State of São Paulo. VANZOLINI (1964) reviewed the natural history of aquatic animals of Brazil. In recent years academic and applied ecological studies of aquatic insects have begun in several research centres. For example, SCHROEDER-ARAUJO & CIPOLLI (1986) studied the benthic invertebrates of Campos do Jordão streams, FERREIRA & FROEHLICH (1992) described the mayfly fauna of Pedregulho Stream, a fourth-order stream in northeastern São Paulo State, and HENRY *et al.* (1994) reported on the input of allochthonous matter and structure of fauna of Itauna Stream in southeastern São Paulo State. A number of theses and technical reports are also available (LOYOLA, 1994). This article is based on a study of the riffle insects of low-order streams in Campos do Jordão (OLIVEIRA, 1988). Information on the habitat preferences of neotropical nymphs of Ephemeroptera and Plecoptera is limited. For some of the wide-ranging mayfly genera, data may be found in EDMUNDS *et al.* (1976) and in MERRITT & CUMMINS (1984); data on habitats of several genera are found in DOMINGUEZ *et al.* (1992) and DOMINGUEZ *et al.* (1994). The authors' experience in field work has also been helpful.

## STUDY AREA AND METHODS

The study area (Fig. 1) was located in the Campos do Jordão State Park, State of São Paulo. This park is situated in the Serra da Mantiqueira, a mountain range located in southwestern Minas Gerais and adjoining parts of the States of São Paulo and Rio de Janeiro. At the study site, elevations are around 1550 m. The region is covered with a mixed Araucaria angustifolia forest and open fields (HUECK & SEIBERT, 1981). The climate is considered to be subtropical of altitude (SCHROEDER-ARAUJO *et al.*, 1986). The lowest temperature measured, 4.5°C, occurred in June, and the highest, 23.3°C, in February (SCHROEDER-ARAUJO *et al.*, 1986). Frosts are common during the winter. Precipitation is around 1500 mm annually.

All the streams studied were in forested areas. Four sampling stations in three streams belonging to the same catchment basin were chosen. Stations 1 and 2 were on two first order tributaries of the Galharada stream. Stations 3 and 4 were on the Galharada stream itself, Station 3 being located near to Station 2 but ca. 2 km upstream from Station 4 (Fig. 1). Both are third order, but Station 4, being downstream of several small tributaries, has a larger water volume. Station 4 differs from the other three because the Galharada upstream passes through cleared areas on the left bank that include a trout-breeding station, a sawmill, a plant nursery, and several houses.

Physico-chemical data on the Galharada stream are presented in SCHROEDER-ARAUJO *et al.*, (1986). Hydrological data for the stations are summarized in Table 1. During our sampling, the measured water temperature in the stations varied between 12.0 and 16.0°C, which are within the range presented by SCHROEDER-ARAUJO *et al.* (1986).

Three samples were taken from riffles: the first on 23.V.1987, the second on 18.XI. 1987 and the third on 13.III.1988. Insects were sampled by lifting the stones in front of a sieve (ca. 1 mm mesh) and then removing the insects from both the stone and the sieve. Sampling was done for 1 hr, and it covered grossly 1 m<sup>2</sup>. This method gives a relative abundance measure of the different taxa, but has an unknown sampling error. The insects were preserved in 80% alcohol.

Ephemeroptera nymphs were initially identified to genera using DOMINGUEZ *et al.* (1992), and later verified, in part, by Dr. E. Dominguez. For the Plecoptera, the species of Gripopterygidae and *Kempnyia* could be named, but those of *Anacroneturia* were designated by letters. Voucher specimens of the insects are deposited in the Zoology Museum, University of São Paulo.

Gut contents of Ephemeroptera and of Gripopterygidae were examined. Guts were extracted from the nymphs, shredded on a slide with glycerin and examined under a microscope. At least two grown nymphs of each genus were examined, and if the contents of both were similar, no further nymphs were examined. For two mayfly genera (*Campylocia* and *Farrodes*), the gut contents of younger

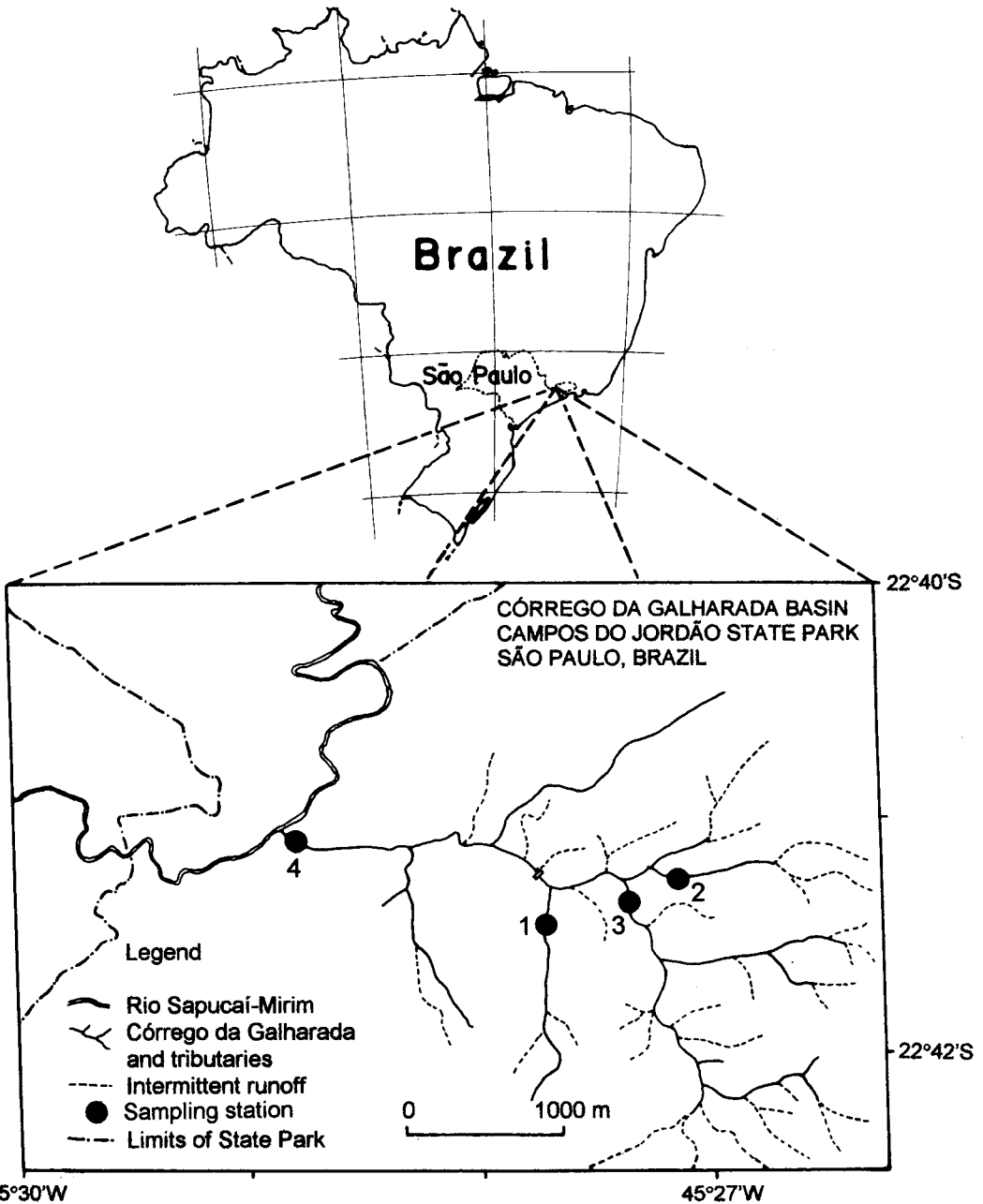


Fig. 1. Sampling stations in the Galharada Stream (Córrego) basin in the Campos do Jordão State Park, São Paulo, Brazil.

nymphs were also examined, but did not differ from those of the large nymphs.

## RESULTS AND DISCUSSION

### *Composition and spatial distribution*

The results are presented in Table 2. The Ephemeroptera included 14 genera in four families. The genera *Askola*, *Farrodes*, *Hagenulopsis*, *Hermanella*, aff. *Hermanella*, *Massartella*, *Leptohyphes* and *Campylocia* were apparently represented by one species each. *Baetis* (s.l.), *Thraulodes* and *Leptohyphes* had at least three species, and *Baetodes* had at least two species. As the distinction between species in these genera was not always easy, we opted to consider the Ephemeroptera only at the generic level. Nymphs of *Askola* are more numerous in pools or at the margins of streams (DOMINGUEZ *et al.*, 1992; personal observations) and thus are not typical riffle inhabitants. Nymphs of *Leptohyphes* are also common at stream margins. *Massartella* is found in a wide range of habitats, from rivulets to larger rivers, and is commonly found associated with fallen leaves, both in erosional and depositional habitats (pers. obs.).

The Plecoptera included a few species of *Paragripopteryx* (*P. klapaleki* was identified, *Paragripopteryx* spp. are chiefly *P. delicata* and *P. blanda*), three species of *Gripopteryx*, and six species each of *Anacroneuria* and *Kempnyia*. *Gripopteryx garbei* is usually found in the upper leaves of leaf packets in riffles or rapids (pers. obs.). *Paragripopteryx* nymphs are also associated with fallen leaves, but are more common where a thin sheet of water runs over

stones (FROELICH, 1994). Among the perlids, *K. colossica* is found chiefly in headwater rapids (pers. obs.).

The Ephemeroptera had almost twice the number of nymphs as the Plecoptera. The most numerous mayfly family was the Leptophlebiidae (60.4% of the total), followed by the Baetidae (23.1%). The five most numerous genera (70% of the total) followed the order: *Thraulodes*, *Baetodes*, *Hermanella*, *Campylocia* and *Hagenulopsis*.

FERREIRA & FROELICH (1992) found seven mayfly genera in their study of the riffles of Pedregulho stream. These were: *Baetodes*, *Baetis*, *Camelobaetidius*, *Hermanella*, *Thraulodes*, *Leptohyphes* and *Lachlania*. The two most numerous were *Baetodes* (33.3% of the total) and *Thraulodes* (28.1%); *Leptohyphes* (16.5%) and *Hermanella* (13.1%) were also important. The stretch of the Pedregulho stream studied runs through an open area of pastures. The altitude, ca. 700 m, is much lower than that of the Galharada stream, so that temperatures are higher - the highest stream temperature measured was 23.5°C. Despite the differences, both streams had six genera in common and the two most abundant were the same. The Plecoptera, however, showed important differences. The only genus present in the sampled area was *Anacroneuria*, which is warm-adapted (ILLIES, 1964). The only gripopterygid, found in shaded upstream portions of the Pedregulho stream, was *Tupiperla* sp. (Froehlich, unpubl. obs.).

In the Galharada stream, the Perlidae (80.9%) were much more numerous than the Gripopterygidae (19.1%). Within the Perlidae, *Anacroneuria* was almost three times as abundant as *Kempnyia* (74.4 vs. 25.6%, respectively). The two most abundant species of Plecoptera were *Anacroneuria* sp. V and *Anacroneuria* sp. Z.

Some taxa were more abundant at stations where the streams were either larger (Stations 3 and 4) or smaller (Stations 1 and 2), but nymphal preference for stream size would be commingled with that for water velocity, for here an increased size is associated with increased velocity which is not fundamental in low-order streams. Three taxa showed a preference for the third-order stations and, especially, for Station 4: *Baetis* (86% of the individuals of

**Table 1.** Mean depth, width and water velocity of the Galharada Stream sampling stations, based on OLIVEIRA (1988).

	Station 1	Station 2	Station 3	Station 4
Order	1	1	3	3
Depth (cm)	14	14,5	18	23
Width (m)	1,6	1,9	3,3	3,9
Velocity (cm/s)	40	38	61	86

this genus were at Stations 3 and 4 combined; 62% at Station 4 only); *Baetodes* (92 and 65%, respectively), and *Gripopteryx juetah* (92 and 77%, respectively). *Baetis* occurs in widely

different habitats (EDMUNDS *et al.*, 1976). *Baetodes* also occurs in a variety of habitats, being common, for example, in rapids as well as in quasi-hygropetric conditions even in first-

**Table 2.** Number of nymphs of Ephemeroptera and Plecoptera collected at each sampling station and sampling period in the Galharada Stream basin of the State Park of Campos do Jordão, São Paulo, Brazil.

Genus/Sampling	Totals per month			Totals per Station				Grand Total	%
	May	Nov.	Mar.	St. 1	St. 2	St. 3	St. 4		
<b>Baetidae</b>								<b>206</b>	<b>23,1</b>
<i>Baetis s.l.</i>	17	31	15	6	3	15	39	63	7,1
<i>Baetodes</i>	44	42	56	0	12	38	92	142	15,9
<i>Camelobaetidius</i>	0	0	1	0	0	0	1	1	0,1
<b>Leptophlebiidae</b>								<b>538</b>	<b>60,4</b>
<i>Hagenulopsis</i>	6	85	11	40	40	21	1	102	11,4
<i>Farrodes</i>	0	50	0	8	14	28	0	50	5,6
<i>Massartella</i>	7	3	9	7	3	3	6	19	2,1
<i>Hermanella</i>	43	70	1	97	6	11	0	114	12,8
<i>Aff. Hermanella</i>	7	35	44	29	11	3	43	86	9,7
<i>Thraulodes</i>	37	82	41	30	66	60	4	160	18,0
<i>Askola</i>	0	7	0	1	3	3	0	7	0,7
<b>Leptohyphidae</b>								<b>41</b>	<b>4,6</b>
<i>Leptohyphodes</i>	5	3	3	3	4	4	0	11	1,2
<i>Leptohyphes</i>	3	15	6	3	0	3	18	24	2,7
Gen.	0	3	3	1	5	0	0	6	0,7
<b>Euthyplociidae</b>								<b>106</b>	<b>11,9</b>
<i>Campylocia</i>	43	15	48	63	41	2	0	106	11,9
Sum Epher.	212	441	238	288	208	191	204	891	
<b>Gripopterygidae</b>								<b>93</b>	<b>19,1</b>
<i>Paragripopteryx spp.</i>	1	21	0	5	7	4	6	22	4,5
<i>P. klapaleki</i>	0	4	0	1	3	0	0	4	0,8
<i>Gripopteryx garbei</i>	0	2	0	0	2	0	0	2	0,4
<i>G. juetah</i>	35	4	9	3	1	7	37	48	9,9
<i>G. pilosa</i>	6	7	4	0	6	11	0	17	3,5
<b>Perlidae</b>								<b>394</b>	<b>80,9</b>
<i>Anacroneturia sp. Z</i>	29	27	42	9	35	45	9	98	20,1
<i>A. sp. X</i>	0	2	0	2	0	0	0	2	0,4
<i>A. sp. W</i>	6	14	4	0	0	0	24	24	4,9
<i>A. sp. V</i>	32	57	50	44	25	45	25	139	28,5
<i>A. sp. U</i>	4	1	6	0	10	1	0	11	2,3
<i>A. sp. T</i>	9	1	1	2	1	4	4	11	2,3
<i>A. juven.</i>	3	3	2	2	0	4	2	8	1,6
<i>Kempnyia neotropica</i>	6	4	15	5	3	4	13	25	5,1
<i>K. aff. vanini</i>	4	2	2	3	1	1	3	8	1,6
<i>K. flava</i>	7	4	6	8	1	8	0	17	3,5
<i>K. obtusa</i>	6	5	5	0	2	6	8	16	3,3
<i>K. colossica</i>	0	2	0	0	1	1	0	2	0,4
<i>K. sp.</i>	2	0	0	2	0	0	0	2	0,4
<i>K. juven.</i>	4	15	12	13	4	5	9	31	6,4
Sum Plecopt.	154	175	158	99	102	146	140	487	

**Table 3.** Gut contents of nymphs of Ephemeroptera and Plecoptera genera collected in the Galharada Stream basin in the Campos do Jordão State Park São Paulo, Brazil. Code: +, present; ++, common; +++, abundant.

	Higher plant fragments		Pollen	Periphyton	Detritus	Sand
	Leaves and soft tissues	Wood				
<i>Baetis</i>	++				+++	+
<i>Baetodes</i>	+			+	+++	
<i>Hagenulopsis</i>	++		++	+	++	++
<i>Farrodes</i>	++		+	+	+++	+
<i>Massartella</i>	+++			+	+++	+++
<i>Hermanella</i> & aff.	+		+	++	+++	++
<i>Thraulodes</i>	++		+	+	+++	++
<i>Askola</i>	+		+	+	+++	++
<i>Leptohyphodes</i>	++			+	+++	+++
<i>Leptohyphes</i>	++			++	+++	+++
<i>Leptohyphidae</i> gen.		+++			++	
<i>Campylocia</i>		+++			++	
<i>Gripopteryx</i>				+++	++	+
<i>Paragripopteryx</i>					+++	

order streams (pers. obs.). *Baetodes* was the most abundant species in the riffles of the Pedregulho stream (FERREIRA & FROELICH, 1992). *Hagenulopsis* and *Campylocia* showed a preference for first-order streams: 78% of *Hagenulopsis* and 98% of *Campylocia* were collected at Stations 1 and 2. Our experience in other field work supports the findings for *Campylocia*. Their nymphs may also be found in larger streams (at least fourth-order, pers. obs.) on sandy substrates covered by stones or wood under which they can retreat, but they are much more common in first and second-order streams. This may be related to a larger supply of fallen branches for shredders in the low-order streams (VANNOTE *et al.*, 1980). Of the taxa collected in smaller numbers, *Anacronuria* sp. W occurred only at Station 4.

#### Feeding habits

The gut contents of the nymphs of the genera collected (except Perlidae) are shown in Table 3. Most Ephemeroptera are collectors or scrapers (MERRITT & CUMMINS, 1984), and all but two genera examined were confirmed as such. The two exceptions are *Campylocia* and *Leptohyphidae* gen., which proved to be wood shredders. The occurrence of pollen grains (mostly gymnosperm pollen) in the guts of most Leptophlebiidae should be seasonal, but the collection dates of the nymphs used for the gut analyses were not recorded. The Gripopte-

rygidae are scrapers. The Perlidae were assumed to be predators (MERRITT & CUMMINS, 1984; pers. obs.).

#### Seasonality

Nymphs of most genera or species did not show any marked seasonality (e.g. *Baetis*, *Baetodes*, *Thraulodes*, *Campylocia*, *Anacronuria* sp. Z and sp. V), but the nymphs of *Hagenulopsis*, *Farrodes* and *Gripopteryx juetah* were highly seasonal. Eighty three percent of *Hagenulopsis* and 100% of *Farrodes* were collected in November, whereas 73% of *G. juetah* were collected in May. *Hermanella* and aff. *Hermanella* also showed a degree of periodicity; only 1% of *Hermanella* was collected in March, and 8% of aff. *Hermanella* were collected in May. This phenomenon should be confirmed by further studies and its importance in life histories assessed. In the case of *G. juetah* the result seems to be due to chance, for in other collections in the area most adults were collected in October and November, and the nymphs did not show such seasonality (FROELICH, 1990).

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