J. Indian Inst. Sci., 66, July 1986, pp. 465–473

Diel periodicity of benthos in riffle regions of polluted Widawka River, Poland

MARIA GRZYBKOWSKA, DARIA PAKULSKA, HENRYK JAKUBOWSKI AND S. RAVICHANDRA REDDY*

Department of Ecology & Vertebrate Zoology, Institute of Environmental Biology, University of Lodz ul Banacha, 12/16, Lodz, Poland.

Received on July 8, 1986.

Abstract

Diel variations in the densities of benthic invertebrates inhabiting the riffle regions of polluted Widawka river, Poland, were studied in spring 1985. Variations in water and sediment temperatures were independent of fluctuations in air temperature. Oligochaetes, crustaceans and chironomids were most dominant in the riffle regions. While crustaceans and oligochaetes displayed a clear night activity pattern, chironomids, molluscs and others failed to indicate any such preference.

Key words: Benthos, diel periodicity, polluted river.

1. Introduction

Quantitative studies on invertebrates of unpolluted streams and rivers suggest that, riffles support higher densities than pools[1–5]. The diel activity patterns of invertebrates in riffle and pool regions of such unpolluted streams and rivers has been the subject of recent studies[6,7]. Further, the daily and seasonal fluctuations in the drift of such habitats are also determined by benthic density[8]. Similarly, diel activity pattern might be expected for invertebrates inhabiting polluted waters. While benthic communities have been used as a criterion to estimate the pollution level in Polish rivers[9–12], there is no information on the drift or diel activity pattern of benthic communities inhabiting polluted rivers. The main objective of this study was to determine the magnitude of diel activity pattern of benthic invertebrates in the riffle regions of the polluted Widawka river.

2. Study area

The investigation was carried out in the lower region of Widawka river (18°55 – 19°28 W; 51°17 – 51°33 N) near Chociw (fig. 1), during spring 1985. The details of river,

* Permanent address: Department of Zoology, Bangalore University, Jnana Bharathi, Bangalore 560 056.

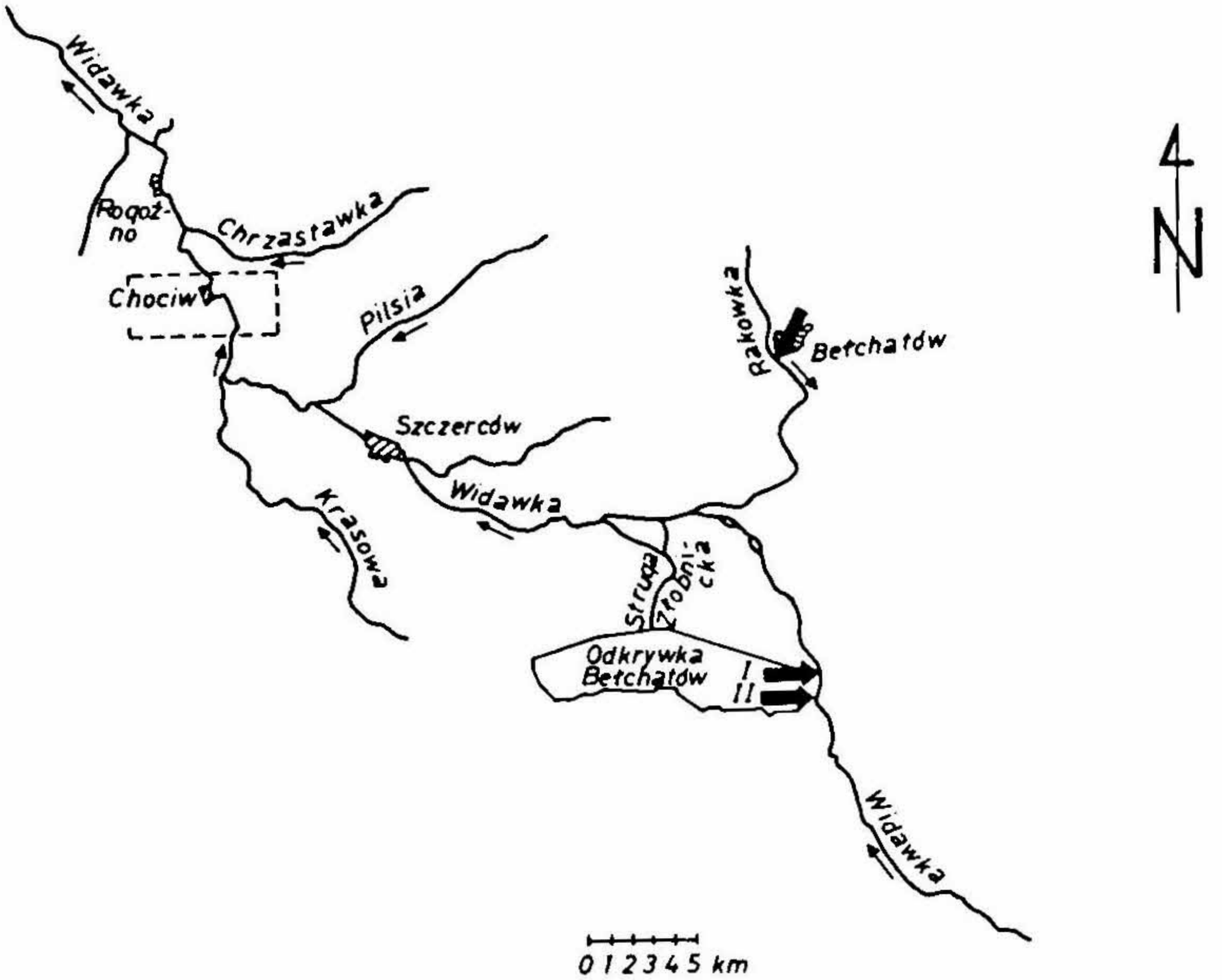

FIG. 1 Widawka river and the study area.

sources of pollution and its impact on fish resources have been published earlier[13–17]. The water flow and temperature regimes of the river are modified by water supply from coal mines at Belchatow[18–19]. Two adjacent riffle regions were selected as the sampling sites. The width of the river at these sites averaged 27 m. In the two riffle regions, the bottom was composed of sand and gravel with sparse aquatic macrophytes.

3. Methods

Benthic samples were collected at successive intervals of 4 h for 24 h during spring 1985. The samples were collected at the two sites using a cylinder sampler (surface area: 10 cm^2). At each site five replicate samples were collected and transferred into separate containers. The catch was sorted immediately in enamel trays and the animals were preserved in 70% alcohol. During each collection, air, water and sediment temperatures and current velocity were measured concurrently with benthos sampling. Current velocity at the two sampling sites was recorded 10 cm below surface layer using a portable current meter. All the animals were identified as far as possible and their density (number/m^2) and biomass (g/m^2) were estimated.

4. Results

Diel fluctuations in air, water and sediment temperatures of riffle region are illustrated in fig. 2a. Since the two riffle regions did not exhibit much variation in the physical parameters, the mean values have been represented. The air temperature indicated significant diel variations. Between 16 and 04 h, the air temperature decreased gradually from 27.5° to 16° C and thereafter it increased steadily reaching the maximum value of 28.5° C at 12 h. In contrast to this, the water and sediment temperatures did not exhibit any diel fluctuations. However, the water temperature always exceeded that of sediment

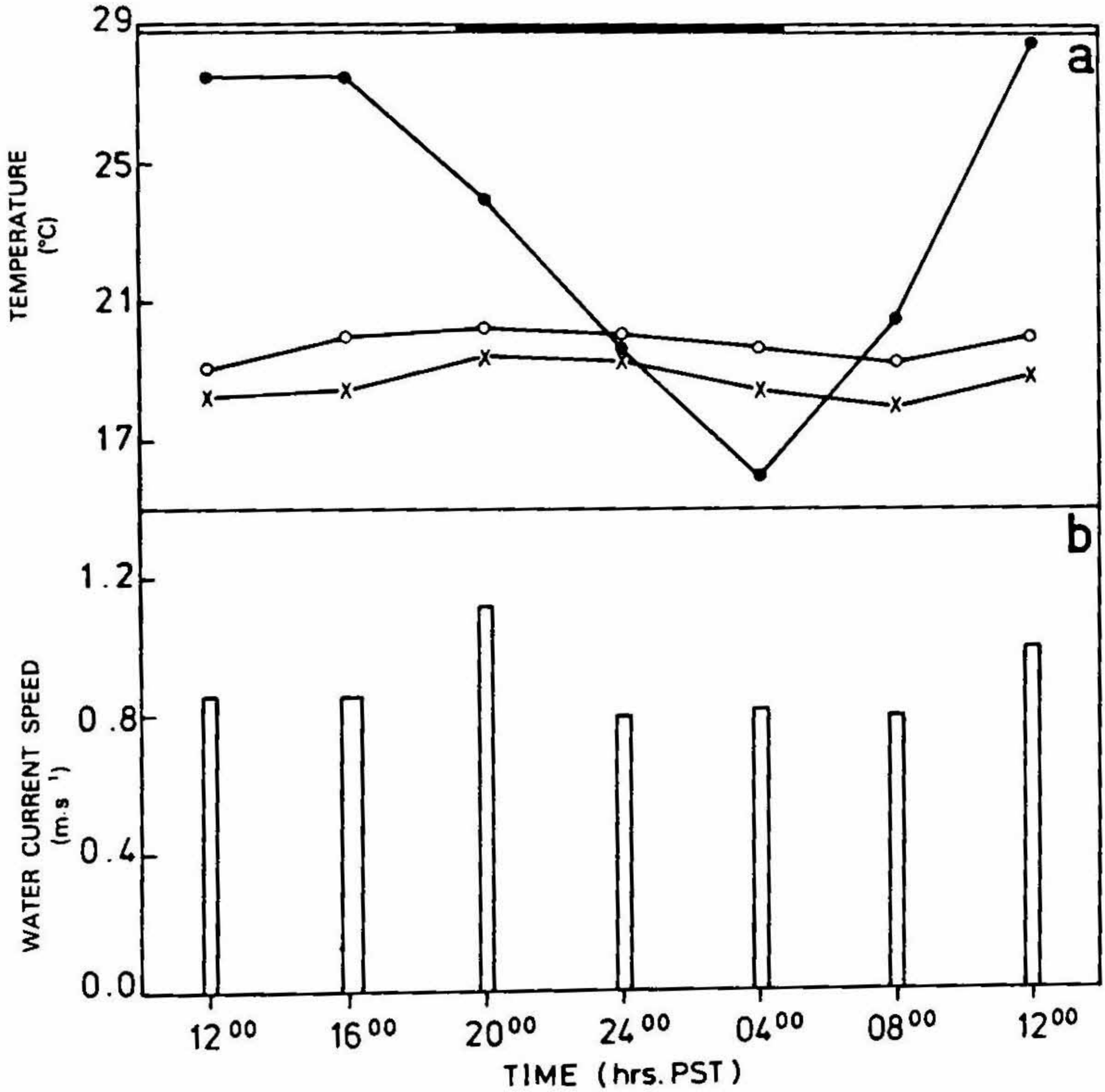

FIG. 2a. Diel fluctuations in air (●—●), water (○—○) and sediment (x—x) temperatures in the riffle region. 2b. Diel fluctuations in water current in the riffle region. Shaded horizontal bar denotes the time between sunset and sunrise.

temperature. The range of changes in water and sediment temperatures during the 24 h period was of the order of 1° and 1.5° C respectively.

As can be seen from fig. 2b, the differences in current speed between the successive collections were not marked. During the 24 h period, the current speed in the riffle region ranged from 0.80 to 1.13 $m.s^{-1}$ and the maximum current speed was recorded at 20 h. This current speed is probably due to the release of water from coal mines (see Wchowiak[18]).

Figure 3 compares the diel fluctuations at successive 4 h intervals in total density and corresponding biomass of bottom fauna in the riffle region. Maximum density of bottom fauna was recorded at the two 12 h periods. During these periods, the biomass also remained high. The riffle regions were equally rich in taxa. The benthic invertebrates belonged to five major groups: Oligochaeta, Crustacea, Insecta, Mollusca and 'others'. The category 'others' includes Porifera, Nematoda and Hirudinea. The relative abundance (expressed as %) of these groups at the different sampling periods are detailed in fig. 4. On the whole, insects were most abundant and numerically represented 46.20%. Oligochaetes formed only 30.00%. Crustaceans (18.56%) were more abundant than the molluscs (3.10%). The density of 'others' remained low (2.14%) in the riffle region.

Table I summarises the species composition of the major groups. Maximum species diversity was observed among Chironomidae. In this family as many as 11 species were recorded. In the two riffle regions, *Polypedilum* gr. *breviantennatum* Tshern was most

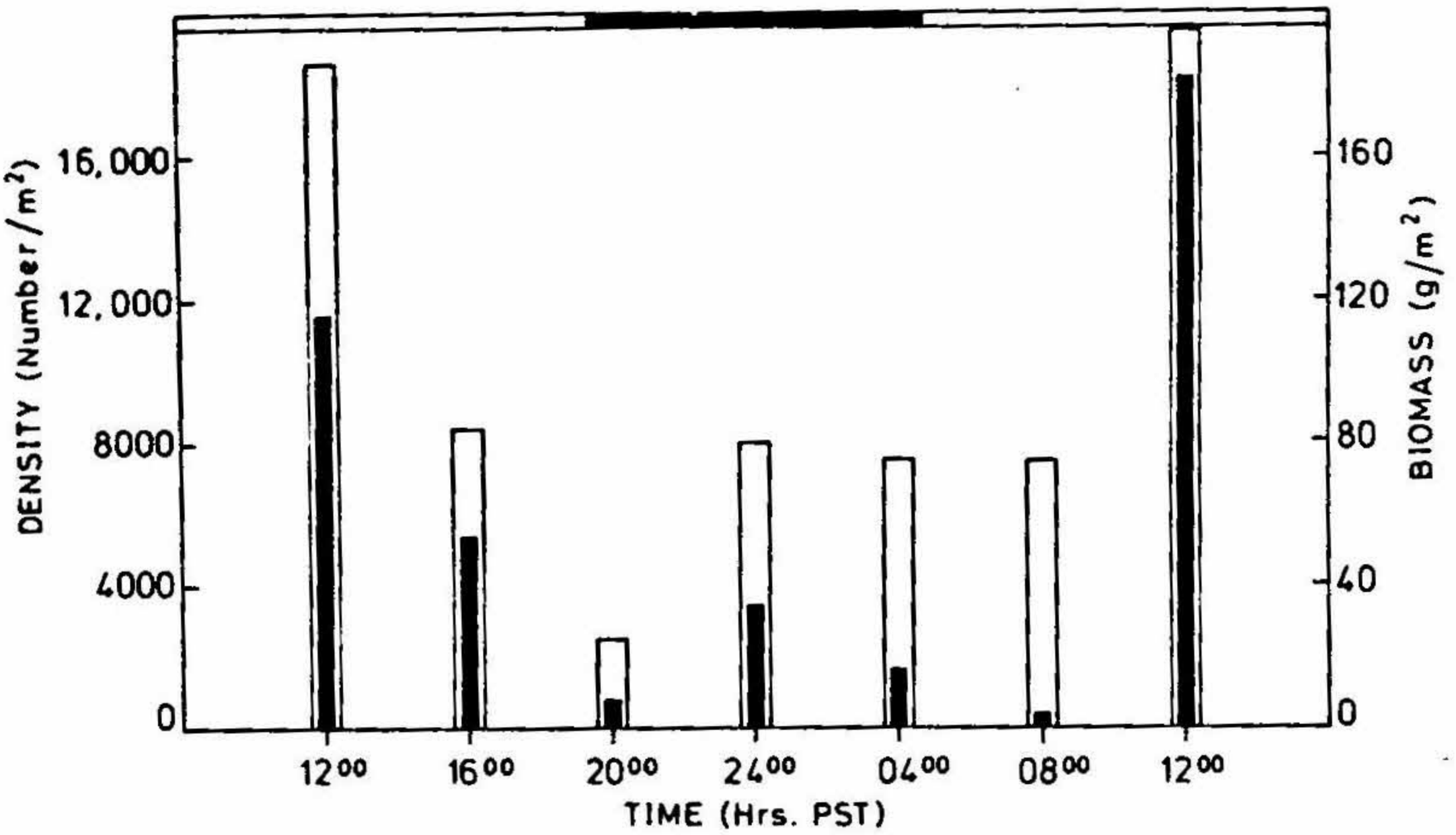

FIG. 3. Diel variations in the density (□) and biomass (■) of benthic invertebrates in the riffle region. Shaded horizontal bar shows the time between sunset and sunrise.

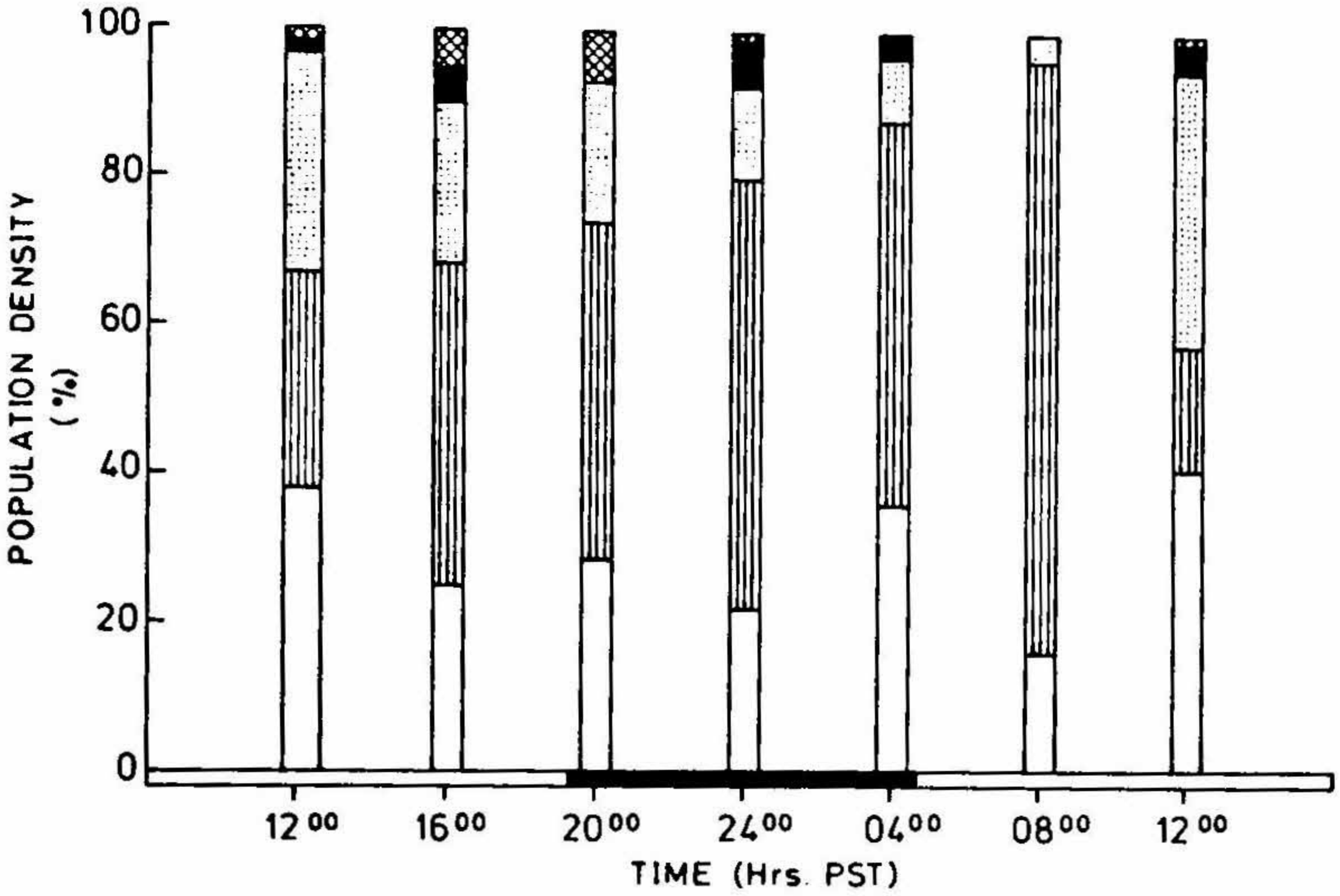

FIG. 4. Percentage composition of the five groups of benthic animals at different sampling periods. The values have been calculated taking the total number of individuals recorded at each sampling. Shaded horizontal bar shows the time between sunset and sunrise (□ oligochaeta, ▤ crustacea, ▥ insecta, ■ mollusca, ▦ others).

dominant. Among the crustaceans *Gammarus fossarum* Koch was most predominant, while *Pisidium* sp. was the most abundant mollusc. The members of the 'others' group did not exhibit any clear dominance pattern.

Diel fluctuations in the composition and quantity of benthic invertebrates were evident in the riffle region (fig. 5), but were not uniform. The density of oligochaetes remained considerably high during the two 12 h periods, thus suggesting a clear nocturnal activity pattern. Similarly, crustaceans also indicated a clear nocturnal activity pattern and were most abundant at the two 12 h periods. In comparison to this, the density of chironomids, though remained high, did not display any clear diel pattern. Members of Ephemeroptera, Trichoptera and Simuliidae were recorded infrequently and as such did not throw light on any particular pattern of their abundance in the 24 h period. Molluscs in the riffle region did not indicate any clear diel pattern of fluctuation in their density. The highest density ($1000/m^2$) in the category 'others' was recorded at the second 12 h period.

5. Discussion

While substantial variations in the air temperature in riffle region of the Widawka river was observed, there was little variation in the water or sediment temperatures. This is

Table I
Major taxa of benthic invertebartes recorded in riffle region of Widawka river

Taxa		Species	
Porifera			+
Nematoda			+
Oligochaeta			+
Hirudinea		*Haemopis sanguisuga* (L.)	+
		Erpobdella octoculata (L.)	+
		Erpobdella sp.	+
Crustacea		*Gammarus fossarum* Koch	+
		Asellus aquaticus Racov	+
Insecta			
	Trichoptera	*Hydropsyche pellucidula* (Curtis)	+
		Arthripsodes sp.	
	Ephemeroptera	*Baetis* sp.	+
	Simuliidae		+
	Diptera larvae		+
	Coleoptera		+
	Chironomidae	*Cryptochironomus gr. defectus* (K.)	+
		Polypedilum gr. breviantennatus Tshern	+
		Polypedilum gr. pedestre (Mg.)	+
		Odontomesa fulva (K.)	+
		Prodiamesa olivacea (Mg.)	+
		Cladotanytarsus gr. mancus (Walk.)	+
		Cricotopus gr. sylvestris (Fabr.)	+
		Paratanytarsus lauterborni (K.)	+
		Polypedilum gr. nubeculosum (Mg.)	+
		Eukiefferiella brevicalcar (K.)	+
		Orthocladius sp.	+
Mollusca		*Pisidium* sp.	+
		Bithynia tentaculata (L.)	+
		Sphaerium sp.	+

+ present.

due to the influence of heated water released from coal mines. The lack of diel temperature fluctuations had little effect on faunal composition and their diel periodicity in the riffle region. Similarly, Pearson and Krammer[20], working on a spring-fed stream with nearly constant temperature have also recorded diel periodicity in drift.

The riffle region was found to support a high standing crop of invertebrates. Similar observations have also been reported for other non-polluted rivers[6,21]. The overall predominance of oligochaetes and chironomids in the two riffle regions clearly reflects the nature of Widawka river. Since they are found to be more resistant to oxygen depletion[22], they appear to colonise the bottom sediments of the river. Within the riffle regions, heterogeneity of particle size is found to be of critical importance in providing varied micro-habitats for supporting an abundant and diverse fauna[23–25]. Of the several species of chironomids recorded, only *Polypedilum* gr. *breviantennatum* Tshern was

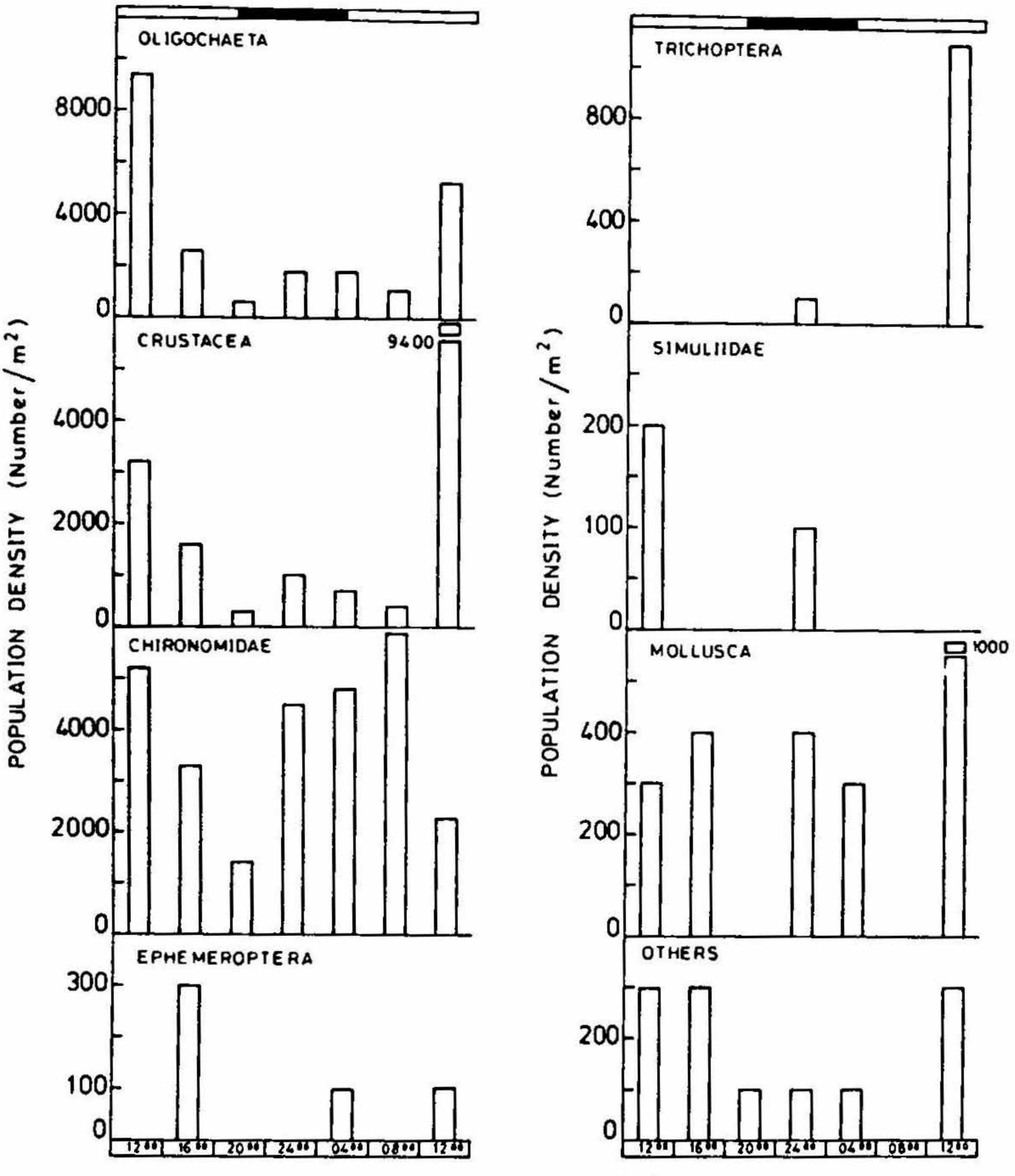

FIG. 5. Diel variations in the population density of different groups of benthic animals in riffle region. Shaded horizontal bar shows the time between sunset and sunrise.

found to be consistently greater. Similarly, the character of the bottom sediment was more suitable for *Gammarus fossarum* Koch. The high association of some animals to the riffle region has also been explained in terms of inherent current requirement associated with respiratory physiology[26].

Bottom fauna are known to display an inherent diel rhythms in their activity pattern and light and temperature may act as 'zeitgebers'[27–31]. The present observations clearly reveal that such diel rhythms are also displayed by the benthic invertebrates inhabiting the riffle regions of the polluted Widawka river. However, there may be differences in the amplitude of their inherent activity. As a result of nocturnal activity, the bottom fauna begin to forage over the upper surfaces of rocks/stones during night and may either move to adjacent areas to take shelter or bury deep in the bottom sediment during the day period. *Gammarus* sp. have been observed to exhibit such a behaviour[32–33]. This may explain the present observation of high density of *Gammarus fossarum* Koch in the substratum during the day periods.

A number of studies on variety of rivers in which a diel rhythm of drift has been found, indicate that plecopterans, ephemeropterans, trichopterans and simuliids drift maximally at night, while chironomids do not exhibit any preference[34,35]. Since drift density is apparently dependent on bottom biota, the present results suggest that, the absence of preferential drift by the chironomids is due to the lack of their diel activity pattern in the bottom sediment.

Acknowledgement

The authors express their thanks to Prof. Tadeusz Penczak, Chairman, Department of Ecology and Vertebrate Zoology for valuable comments on the manuscript. Technical assistance provided by Włodzimierz Fiet is gratefully acknowledged. SRR is grateful to the University of Łodz for providing financial assistance during the stay in Poland.

References

1. Egglishaw, H.T. and Nacky, D.W. — *Hydrobiologia*, 1967, **30**, 305–334.
2. Mundie, J.H. — *J. Fish. Res. Bd. Can.*, 1971, **28**, 849–860.
3. Armitage, P.D., Machale, A.M. and Crisp, D.T. — *Freshwat. Biol.*, 1974, **4**, 369–398.
4. Scullion, J. — *M.Sc. Thesis*, University of Wales, 1977.
5. Logan, P. and Brooker, M.P. — *Wat. Res.*, 1983, **17**, 263–270.
6. Scullion, J., Parish, C.A., Morgan, N. and Edwards R.W. — *Freshwat. Biol.*, 1982, **12**, 579–595.
7. Graesser, A. and Lake, P.S. — *Hydrobiologia*, 1984, **111**, 153–160.
8. Cowell, B.C. and Carew, W.C. — *Freshwat. Biol.*, 1976, **6**(6), 587–594.

9. KLEKOT, A. *Pol. Arch. Hydrobiol.*, 1972, **19**(2), 151–166.
10. DUSOGE, K. AND WISNIEWSKI, R.K. *Pol. Arch. Hydrobiol.*, 1976, **23**, 539–554.
11. SZCZESNY, B. *Acta Hydrobiol.*, 1974, **16**, 1–29.
12. WIELGOSZ, S. *Acta Hydrobiol.*, 1979, 21(2), 149–165.
13. MIKULSKI, Z. *Zarys hydrografii Polski PWN*, Warszawa, 1963.
14. STRAXZEWICZ, L. *Wojewodztwo Lodzkie, Zarys geografiozno – Ekonomiczny PWN*, Warszawa, 1963.
15. PENCZAK, T. *Acta Hydrobiol.*, 1969, **11**(1), 69–118.
16. JAKUBOWSKI, H. AND PENCZAK, T. *Gospodarka Rybna*, 1984, **4**, 20–22.
17. JAKUBOWSKI, H., MANN, R.H.K. AND PENCZAK, T. *Folia Universitatis Lopzienzis*, 1985.
18. WCHOWIAK, G. *Instytut Meteorologii Igospodarki Wodnej addziak w Poznania*, 1984, p. 8.
19. WCHOWIAK, G. *Instytut Meteorologii Igospodarki Wodnej addziak w Poznania*, 1985.
20. PEARSON, W.D. AND KRAMER, R.H. *Ecol. Monogr.*, 1974, **42**, 365–385.
21. MINSHALL, G.W. AND MINSHALL, J.N. *Hydrobiologia*, 1977, **53**, 231–249.
22. KOWNACKI, A. *Acta Hydrobiol.*, 1982, **24**(4), 375–390.
23. HYNES, H.B.N. *The ecology of running waters*, Liverpool University Press, 1970, p. 555.
24. GIGER, R.D. *Oregon Wildlife Commission Federal Aid progress*, 1973, Report No. AFS, 62–1.
25. WARD, J.V. *Instream flow needs symposium* (Eds. J. F. Osborn and C. H. Allman), 1976, **II**, 235–253.
26. JAAG, O. AND AMBUHL, H. *Advances in water pollution research*, 1964, **1**, 31–49.
27. ELLIOTT, J.M. *Arch. Hydrobiol.*, 1967, 63(2), 202–237.
28. MULLER, K. *Z. Morph. Oikol. Tiere*, 1966, **56**, 93–142.
29. HOLT, C.S. AND WATERS, T.F. *Ecology*, 1967, **48**, 225–234.
30. WALLACE, P.R., HYNES, H.B.N. AND KAUSHKI, N.R. *Freshwat. Biol.*, 1975, **5**, 533–546.
31. HIROKI, M. *Pol. Arch. Hydrobiol.*, 1982, **29**(2), 331–342.
32. WATERS, T.F. *Ecology*, 1966, 47(4), 595–604.
33. ELLIOTT, J.M. *J. Anim. Ecol.*, 1971, **40**, 235–252.
34. HYNES, J.D. *Freshwat. Biol.*, 1975, **5**, 71–83.
35. ARMITAGE, P.D. *Freshwat. Biol.*, 1977, **7**, 167–184.