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Effect of a Total Solar Eclipse on Stream Drift

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Abstract

Stream drift was recorded in the Acheron River, Victoria, on 23 October 1976. A total solar eclipse occurred at 1640–1643 h (Eastern Standard Time). No noticeable effect on the number or types of animals drifting was observed.

Introduction

The importance of light as a control of drift by stream invertebrates has been clearly shown by the use of artificial light regimes in both the field (Elliott 1965, 1967; Holt and Waters 1967) and laboratory (Bishop 1969; Chaston 1969). These studies have shown that drift of night-active animals increases during periods of darkness and decreases during periods of light. The occurrence of a total solar eclipse in Victoria on 23 October 1976 provided an opportunity to determine what, if any, effect a relatively brief but natural and total period of darkness had upon drift.

Description of Locality and Methods

The Acheron River rises on Mount Richie in the Great Dividing Range, some 75 km north-east of Melbourne, Victoria. A permanent stream approximately 70 km long, it flows northward to join the Goulburn River near Acheron. Its upper catchment is covered with wet sclerophyll forest dominated by mountain ash, *Eucalyptus regnans* F. Muell. *Leptospermum lanigerum* Sm. dominates the riverside vegetation.

The sampling site in the upper reaches of the Acheron River, 400 m above sea level, south-east of Narbethong, was just south of the centreline of the umbra. The ecology of the river has been studied by MacMillan (1975). She noted that discharge, measured near the confluence with the Goulburn River, varied annually between 10 and 60 Ml month^{-1}. Conductivity is *c.* 300 μS in the upper reaches.

A steel frame sampler designed for rapid net changes was placed in a riffle zone with a rocky substrate (rocks <8 cm diameter). The depth at the sampler was 0·29 m. The nets of 0·5 mm aperture nylon mesh had a square mouth with a sampling area of 0·1 m^2 and effectively sampled 0·09 m^2. Each net was left in place for exactly 1 h and then changed. Actual net removal times were at 40 min past the hour so that a net was removed immediately prior to the period of total solar eclipse. Sampling was from 0240 to 2240 h Eastern Standard Time (EST) on 23 October.

Samples were either sorted in the field or preserved in 10% formalin and sorted later in the laboratory. Measurements of light intensity were made using a Metrix meter (lux units). To check that no significant current changes occurred during the investigation, current speed was estimated with a Pitot tube; there was no marked change.

A benthic sample was collected on 24 October when 1 h was spent collecting a comparative sample in the vicinity of the drift sampler.

Table 1. Fauna of drift and non-drift samples

L, larvae; P, pupae

Taxon	Drift samples No.	Drift samples %[A]	Non-drift samples No.	Non-drift samples %[A]
Aquatic animals				
Amphipoda				
Paramoera fontana	36	8	82	45
Ephemeroptera				
Atalophlebia cf. *longicaudata* (L)	3	<1	3	2
Atalophlebia sp. (L)	4	<1	0	0
Atalonella sp. (L)	87	20	0	0
Coloburiscoides cf. *giganteus* (L)	12	3	0	0
Baetis sp. (L)	10	2	16	9
Atalophlebioides sp. (L)	0	0	21	12
Plecoptera				
Acruroperla atra (L)	5	1	0	0
Austropentura victoria (L)	2	<1	0	0
Dinotoperla sp. (L)	2	<1	0	0
Dinotoperla arenaria (L)	3	<1	0	0
Dinotoperla brevipennis (L)	3	<1	0	0
Dinotoperla cf. *eucumbene* (L)	1	<1	0	0
Dinotoperla fontana (L)	1	<1	0	0
Eunotoperla kershawi (L)	0	0	1	<1
Illiesoperla australis (L)	10	2	0	0
Leptoperla sp. (L)	3	<1	0	0
Neboissoperla alpina (L)	1	<1	0	0
Riekoperla karki–reticulata group (L)	33	7	22	12
Riekoperla tuberculata (L)	4	<1	0	0
Stenoperla cf. *australis* (L)	1	<1	0	0
Trinitoperla nivata (L)	2	<1	2	<1
Trinotoperla yeoi (L)	2	<1	0	0
Trichoptera				
Leptoceridae (L)	16	4	0	0
Hydropsychidae (L)	15	3	0	0
Sericostomatidae (L)	22	5	1	<1
Philopotamidae (L)	12	3	0	0
Rhyacophilidae (L)	2	<1	0	0
Polycentropodidae (L)	4	<1	2	1
Limnephilidae (L)	2	<1	0	0
Tasimiidae (L)	6	1	6 (P)	3
Psychomyiidae (L)	3	<1	1	<1
Diptera				
Simuliidae (L)	19	4	2	1
Simuliidae (P)	0	0	2	1
Chironomidae (L)	5	1	11	6
Tipulidae (L)	11	2	0	0
Blephariceridae (L)	0	0	5	3
Culicidae (L)	2	<1	0	0
Coleoptera				
Larvae (mainly Helodidae)	71	16	1	<1
Adults	23	5	2	1
Oligochaeta	3	<1	2	1
Mollusca				
Pisidium sp.	1	<1	0	0
Terrestrial animals[B]	97	—	—	—

Results

A list of the fauna in drift and benthic samples is given in Table 1; Table 2 summarizes the hourly results on the basis of major taxa recorded. Table 3 records detailed light readings immediately prior and subsequent to the eclipse. Fig. 1 shows the numbers of total aquatic animals in the drift samples and light intensity against time. Current speed in the riffle during the investigation was between 50 and 70 cm s^{-1}, and water temperatures were between 8·0 and 9·2°C.

Although drift increased after sunset (1910 h EST) there was no significant increase after the period of totality.

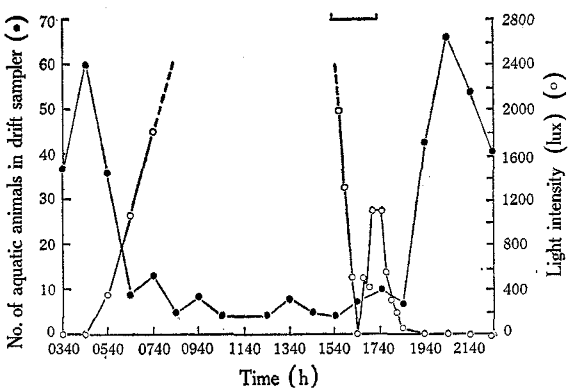

Fig. 1. Number of aquatic animals in the drift samples and light intensity on 23 October 1976. The period of solar eclipse is shown by the horizontal bar.

Discussion

The depressant effect of light on stream drift has been clearly shown (Elliott 1965, 1967; Holt and Waters 1967; Bishop 1969; Chaston 1969, 1972) with light threshold values as low as 10^{-2}–10^{-3} lux (Bishop 1969). This low threshold explains the observation by Holt and Waters (1967) that a partial eclipse of the sun in 1963 produced no increase in drift. The same authors, however, during a continuous light trial recorded a slight temporary increase of drift of *Baetis vagans* McDunnough and *Gammarus pseudolimnaeus* Bousf. after a brief failure of a generator some 2 h after sunset resulting in 'about 3 minutes' of total darkness. This observation was clearly shown in hourly samples; the same frequency was used in the present study. More frequent sampling such as used by Elliott (1969; 1970: 30 min) and Chaston (1969: 15 min) would have produced data easier to analyse but a balance between effort and results was considered necessary over the 24-h duration of the study.

The observation of Holt and Waters (1967) that 'about 3 minutes' of darkness initiated drift during a continuous light trial does not contradict the result recorded in the present study, mainly because of the differences in the experimental conditions. Elliott (1965) observed that 'advancing the onset of darkness induced early onset of drift'. Chaston (1969) suggested it was the onset of darkness which caused the increase in activity which resulted in increased drift, and that this variation was

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[A] Percentage of total aquatic animals.

[B] Aerial stages of aquatic forms plus terrestrial forms, *sensu stricto*, of Orthoptera, Formicidae, other Hymenoptera, Hemiptera, Collembola, Myriapoda, Ephydridae, Empididae, Sciaridae and Arachnida.

Table 2. Numbers of the major aquatic taxa drifting in each hourly sample

Taxon / Time (h):	0240–0340	0340–0440	0440–0540	0540–0640	0640–0740	0740–0840	0840–0940	0940–1040	1040–1140	1140–1240	1240–1340	1340–1440	1440–1540	1540–1640	1640–1740[A]	1740–1840	1840–1940[B]	1940–2040	2040–2140	2140–2240
Amphipoda	2	4	3	1	—	1	—	1	—	—	—	—	—	—	—	2	5	2	5	3
Ephemeroptera	12	20	14	3	2	—	1	—	—	2	1	2	1	2	6	—	11	16	16	12
Plecoptera	11	13	5	—	—	—	2	1	—	—	1	—	—	1	—	2	9	13	7	8
Trichoptera	6	11	6	2	5	3	1	1	1	—	2	1	1	1	1	1	3	15	12	6
Simuliidae	3	3	1	—	—	—	—	—	1	2	—	—	1	2	—	1	4	1	—	—
Chironomidae	1	—	—	—	—	—	—	—	—	—	2	—	—	—	—	1	1	—	1	—
Tipulidae	—	—	2	1	1	—	1	1	—	—	—	—	1	—	1	—	1	—	—	—
Coleoptera																				
Larvae	2	7	4	—	1	—	—	—	2	—	—	—	—	—	—	—	7	15	8	11
Adults	—	2	—	—	1	—	1	—	—	—	2	2	—	1	2	1	2	3	5	1
Other Diptera	—	—	1	2	2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Oligochaeta	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—

[A] Total eclipse sample. [B] Sunset sample.

entirely exogenous. However, during darkness the overall activity is increased and thus the endogenous activity patterns are amplified to a level sufficient also to be reflected in drift. Elliott (1968), using mayfly nymphs, concluded that their activity pattern involved an exogenous periodicity resulting from the onset of darkness, and an endogenous diel activity with light as a time cue. The extended light period in Holt and Water's experiment suppressed the endogenous activity pattern of *Gammarus pseudolimnaeus* and *Baetis vagans* for 2 h after sunset, resulting in a greater activity during the short period of darkness that occurred. During the total solar eclipse the endogenous activity of the benthos is normally low, and a similar-length dark period was probably not long enough to induce early onset of drift.

Table 3. Light intensity readings during the partial and total phases of the solar eclipse

Time	Light (lux)	Time	Light (lux)
1540	>2000	1705	730
1555	>2000	1710	430
1610	1300	1715	1350
1625	500	1720	1225
1640	0	1725	1100
1645	50	1730	1100
1650	240	1735	1100
1655	500	1740	1100
1700	700		

During the solar eclipse a gradual decrease in light intensity for 35 min was observed (Fig. 1), culminating in a sudden decrease to totality at 1640 h EST. The threshold value of <1 lux was not observed prior to totality. The period of totality of almost 3 min resulted in no apparent increase in numbers of drifting organisms. Increases in drift were recorded only during night samples, an increase occurring in the sample immediately after sunset in which the period of darkness sampled was 30 min. McLay (1968) recorded a time lapse of 0·5–1 h after sunset for the peak of drifting to occur; thus, it is suggested that the period of darkness observed during the eclipse was not long enough to initiate activity.

Predictably (e.g. Kroger 1974), several drift components were 'over-represented' in relation to their occurrence in the benthic sample and *vice versa*. While comparison between drift and benthic samples can scarcely be taken far, it is obvious that some species were more frequently recorded in drift samples than their frequency in the benthic sample would suggest they should have been.

In conclusion the results obtained suggest that the period of darkness during the solar eclipse was not long enough to induce activity of any species to a level sufficient to be reflected in drift.

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