Mountain Streams of the Barberton Area, Eastern Transvaal. Part II, the Effect of Vegetational Shading and Direct Illumination on the Distribution of Stream Fauna

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(with 1 fig. and 6 photos)

INTRODUCTION

During the general survey (Part I), it was noted that many reaches of the streams differed primarily with respect to shading. Some regions were densely shaded by overhanging trees and encroaching vegetation, others were completely exposed to direct sunlight.

Mention has been made in the literature of some of the indirect chemical and physical results of shading and illumination (WELCH, 1952; COKER 1955), but only one small general investigation into the importance of these factors has been conducted (HARRISON & ELSWORTH, 1958). The results of this are not very informative as the numbers of samples was small and they were taken from stations on separate streams. Other than this, only scattered references to the importance of illumination as a limiting factor appear in the literature. ZAHAR (1951) discussing an investigation of the Simuliidae in Scotland states that 'our experience has been that *Simulium* larvae are absent from streams closely overhung by the foliage of trees'.

The investigation reported here was therefore an attempt to

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examine the extent to which the distribution of the stream fauna is influenced by direct or indirect consequences of shade or illumination and to determine which species or groups are affected. No attempt is made, however, to determine which factor or interaction of factors are responsible for the qualitative or quantitative differences found between the shaded and open sampling stations.

Choice of streams and sampling stations

Three pairs of comparable sampling stations were chosen. One of each pair was open to direct sunlight and the other was shaded by dense vegetation. They were chosen on a basis of the physical similarity of their stickles and backwaters. Current-speed, depth, number of stones breaking the surface, nature of substratum and stone size were taken into account. (Plates I, II and III).

The streams chosen and the station numbers were:

Station 1. Lomati Stream (Open)
2. Lomati Stream (Shaded)

8. Concession Creek (Shaded)
9. Concession Creek (Open)

6. Lower reaches Hislops Creek (Shaded)
10. Sawmill Creek (Open)

(The stations coupled above are the open and shaded stations from which the samples were considered to be directly comparable.)

It can be seen (Fig. 2, Part I) that in the case of both the first pair (Stations 1 and 2) and the second pair (Stations 8 and 9) the shaded and open stations of each pair are on the same streams, whereas Stations 6 and 10 of the third pair are on different streams.

Sampling procedure and methods

Seven samples were taken at each station in mid-winter (early July): five from stickles and two from backwaters. However the problem of obtaining quantitatively comparable samples from backwaters was insuperable, and these results have been discarded.

The samples from the stickles, coming from such a relatively uniform habitat, were more directly comparable, and were collected in two ways:

(i) Stations 8, 9, 6 and 10 were sampled with a one sq. ft Surber sampler. The larger stones within the one square foot area were given

a preliminary shaking before being removed to a bucket, in which they were thoroughly scrubbed with a coarse brush to remove all torrenticolous forms. The remaining smaller stones and gravel were then rigorously stirred up by hand.

(ii) Stations 1 and 2 did not lend themselves easily to Surber sampling, and were, consequently, sampled with a "*cascade-net*". This net has a metal frame which is firm on all but the lower rim. The lower rim is easily bent into the shape of the stream bed and minimises loss of animals. An area of one square foot, upstream of the net, was marked off, and as in the case of the Surber sampler, all stones were removed to a bucket for scrubbing, while the remaining gravel and smaller stones were stirred about.

The animals and debris in both the bucket and sampler net were placed in twelve-ounce collecting jars, a few ml of 40% formalin was added, and the sample was later examined in the laboratory.

Shade and direct illumination as factors in the distribution of stream fauna

The occurrence and relative abundance of stream animals in shaded reaches and reaches exposed to direct illumination may be a function of (i) one or more indirect factors associated with shade and illumination, or (ii) may be a function of the response of the animals to shade or light itself, e.g. animals whose distribution within the stream is a function of their tactic and kinetic responses to light stimuli.

Some possible indirect effects of stream shading and illumination are listed and discussed below.

Algal growth

The intensity of illumination has a considerable effect on algal growth, which is invariably reduced in a shaded stream. The algae are an important food source, the presence or absence of which may favour or limit certain species. An increase in algal growth was noticed at the open station of each comparable pair, the greatest difference between Station 9 (open) and 8 (shaded) on Concession Creek.

Temperature

The importance of temperature as a limiting factor in stream ecology has been emphasized. Many workers in this field have rated temperature as a primary determinant of distribution (Ricker, 1934; Sprules, 1947; Zahar, 1951; Ide, 1953). Harrison & Elsworth

(1958) found that winter temperatures of shaded streams were higher, and summer temperatures lower than those of comparable open streams. This was not the case here, however, the water temperature at the shaded station was always lower than that at the comparable open station in both summer and winter. These differences never exceeded 3°C for readings taken on the same stream.

Oviposition

Ovipositing females of several species of mosquitoes have been found to be attracted to dark places (BUXTON & HOPKINSON, 1927, JOBLING, 1935 and MUIRHEAD-THOMSON, 1951). One can therefore postulate that similar factors may operate with regard to other species. Yet MACAN (1961) believes that "the eventual pattern of the distribution of nymphs is likely to be due to mortality of those lodged in unsuitable places, rather than to maternal selection".

Vegetational pattern and mechanical obstruction

It has been shown that hawking dragonflies have preferences for distinct types of vegetational patterns (DIVER, 1944), and that *Anopheles culicifacies* is prevented from carrying out a flight essential for oviposition by rice over 30 cm in height (RUSSELL & RAO, 1942). ZAHAR (1951) reports that particular types of vegetation within and flanking rivers are selected by Simuliidae larvae, pupae and adults. It is therefore probable that the presence of thick and low overhanging bushes and trees may act as a physical deterrent to the ovipositing females of many species.

Organic debris

Due to the often dense surrounding vegetation, shaded streams have a greater accumulation of organic debris. Such debris, consisting principally of decomposing leaves, changes to varying extents the nature of the substratum, is a food source and may alter the pH of the water.

RESULTS

Stations 1 (open) and 2 (shaded)–Lomati Stream

Both stations were on the same stream, separated by a distance of about 1,000 m. The open station (1) was upstream from the shaded station (2): they were open and shaded respectively for a considerable distance both upstream and downstream of the sampling stations.

TABLE I

The quantitative sampling results from stations 1 (*open*) *and* 2 (*shaded*), *lomati stream.*

The figures given represent the numbers of individuals per 900 sq. cm.

	Station 1 - Open					Station 2 - Shaded				
	1	2	3	4	5	1	2	3	4	5
TURBELLARIA										
Planaria spp.	6	1	—	—	1	2	1	—	1	2
NEMERTEA										
Prostoma sp. 1	1	3	—	—	—	—	—	1	4	1
NEMATODA	—	36	—	—	16	8	16	—	15	9
OSTRACODA	8	—	—	10	—	—	16	—	17	1
COPEPODA	—	—	—	—	—	—	—	—	17	—
HYDRACARINA	70	28	16	32	64	62	1	30	17	—
PLECOPTERA										
Neoperla spio (NEUMAN)	—	4	—	—	—	—	—	—	—	—
EPHEMEROPTERA										
Pseudocloeon maculosum CRASS	—	—	—	—	—	1	—	—	—	—
Baetis harrisoni BARN.	141	232	146	131	225	174	191	171	120	51
Centroptilum excisum BARN.	—	—	1	1	—	—	—	—	—	—
Caenidae sp. 1	6	7	—	6	4	10	57	16	6	9
Tricorythus discolor BURM.)	2	3	1	—	1	37	52	25	4	16
Afronurus harrisoni BARN.	—	—	—	—	—	—	1	1	—	—
ODONATA										
Aeschna rileyi CALVERT	—	2	1	—	2	—	1	1	—	2
Zygonyx sp. 1	—	1	—	—	—	—	—	—	—	—
TRICHOPTERA										
Cheumatopsyche ? afra	—	—	—	—	—	—	—	1	1	—
Hydroptila undescribed sp. det. SCOTT	2	—	—	—	—	—	—	—	—	—
Hydroptila ? cruciata	4	1	—	—	—	—	—	—	—	—
Orthotrichia sp. 1	6	—	—	—	—	—	—	—	—	—
COLEOPTERA										
Orectogyrus sp. 1	2	3	—	9	9	—	1	1	—	—
Hydraenidae adult (N.I.W.R. type B)	—	—	—	—	—	—	—	—	1	—
Elmidae larvae (N.I.W.R. type 1)	—	—	—	—	—	21	—	16	—	—
Elmidae larvae (N.I.W.R. type 2)	—	4	1	5	5	7	—	7	6	4

TABLE I (Continued)

	Station 1 - Open					Station 2 - Shaded				
	1	2	3	4	5	1	2	3	4	5
COLEOPTERA (Cont.)										
Elmidae larvae (N.I.W.R. type 6)	—	—	—	2	16	37	1	—	1	—
Elmidae adult (N.I.W.R. type V)	—	—	—	—	—	2	—	—	2	—
Ptilodactylidae larvae sp. 1	—	—	—	—	—	1	—	1	1	2
DIPTERA										
Tipulidae sp. 4	—	—	—	—	—	1	—	—	—	—
Tipulidae sp. 8.	—	—	14	6	8	4	2	34	2	8
Simulium spp.	102	131	46	267	108	306	202	244	97	74
Pentaneura spp.	4	—	—	—	—	—	18	—	3	20
Orthocladinae spp.	88	6	37	35	3	—	35	3	33	—
Orthocladinae sp. 1	—	—	—	—	—	—	—	1	1	—
Orthocladinae sp. 2	—	—	—	—	2	—	—	—	—	—
Orthocladinae sp. 4	—	—	—	—	48	—	—	16	—	1
Orthocladinae sp. 11	—	—	—	—	—	—	1	—	—	—
Orthocladinae sp. 12	—	—	—	2	2	—	—	2	—	—
Orthocladinae sp. 14	33	17	—	17	—	1	—	1	—	2
Orthocladinae sp. 15	6	15	2	4	—	—	—	—	—	—
Orthocladinae sp. 17	—	—	—	—	32	—	—	—	—	—
Chironomini sp. 5	—	—	—	—	2	—	—	—	—	—
Chironomini sp. 7	—	—	4	—	—	—	—	—	—	—
Tanytarsus spp.	—	—	—	—	—	—	—	—	—	8
Tanytarsus sp. 4	10	3	7	2	21	9	7	1	52	13
Tanytarsus sp. 13	—	—	—	—	—	—	1	16	—	—
Tanytarsus sp. 15	47	40	120	165	148	112	73	48	113	45
Bezzia spp.	—	1	1	—	—	—	—	—	—	8
Rhagionidae (nr. *Atherix* sp.)	—	—	—	—	—	—	1	—	—	—
Empididae sp. 1	—	—	—	—	2	—	—	—	—	1
MOLLUSCA										
Burnupia sp.	21	7	—	—	8	28	110	40	159	71
TOTAL NUMBER OF ORGANISMS	559	545	397	694	727	823	788	677	674	348

Stations 8 (shaded) and 9 (open) – Concession Creek

The two stations were 500 m apart on the same stream; the shaded station (8) being upstream of the open station (9). They were shaded and open respectively for at least 100 m both upstream and downstream of the sampling stations.

TABLE II

The quantitative sampling results from stations 9 (*open*) *and* 8 (*shaded*), *Concession creek.*

The figures given represent the number of individuals per 900 sq. cm.

	Station 9 - Open					Station 8 - Shaded				
	1	2	3	4	5	1	2	3	4	5
TURBELLARIA										
Planaria spp.	3	4	—	11	7	1	—	—	1	2
NEMATODA	—	—	2	—	—	—	—	—	—	—
OLIGOCHAETA										
Lumbriculus sp.	—	—	—	—	—	—	5	8	—	—
COPEPODA	—	—	—	12	—	—	—	—	—	—
OSTRACODA	—	—	3	12	—	13	—	2	5	12
AMPHIPODA										
Talitroides sp.	—	—	—	—	—	—	—	—	1	—
HYDRACARINA	64	28	72	76	114	33	60	75	200	66
PLECOPTERA										
Neoperla spio	—	—	—	1	—	—	—	—	—	—
EPHEMEROPTERA										
Pseudocloeon undescribed species. det. AGNEW (N.I.W.R. type VAL 1019 B)	2	16	—	—	—	—	—	—	—	—
Baetis harrisoni	142	67	84	37	58	2	10	1	18	4
Acentrella natalensis CRASS	—	—	—	—	—	—	—	—	1	—
Centroptilum excisum	1	—	6	—	—	—	—	—	—	—
Caenidae sp. 1	91	138	149	84	95	39	39	61	46	26
Tricorythus discolor	—	—	—	—	1	19	11	8	9	1
Euthraulus elegans BARN.	40	43	21	63	25	4	4	9	7	4
Afronurus harrisoni	—	—	—	1	—	3	5	4	3	2
ODONATA										
Chlorolestes sp.	—	—	—	—	—	1	—	2	—	—
Paragomphus cognatus RAMB.	3	2	2	—	1	2	—	1	—	1
Aeschna rileyi	1	1	—	—	1	1	1	1	—	1
Zygonyx sp.	3	1	—	1	2	—	—	—	1	—
HEMIPTERA										
Micronecta piccanin HUTCH.	—	—	—	—	—	1	—	—	—	—

TABLE II (Continued)

	Station 9 - Open					Station 8 - Shaded				
	1	2	3	4	5	1	2	3	4	5
TRICHOPTERA										
Leptocerinae sp.	—	—	—	—	—	—	2	—	—	—
Cheumatopsyche ? thomasetti	3	12	13	32	26	—	2	—	—	—
Cheumatopsyche ? afra	53	58	—	9	33	—	35	—	30	5
Chimarra spp.	2	2	7	11	18	—	1	—	15	2
Hydroptila undescribed sp. det. SCOTT	—	—	—	—	—	1	—	2	—	—
Hydroptila ? cruciata	1	2	4	3	6	—	—	—	—	—
COLEOPTERA										
Orectogyrus sp.	5	2	—	1	2	—	4	—	2	—
Psephenidae sp. 1	—	—	—	—	—	3	1	—	2	1
Elmidae larvae (N.I.W.R. type 1)	—	—	—	7	2	15	15	7	16	33
Elmidae larvae (N.I.W.R. type 2)	—	—	—	—	—	1	2	—	—	—
Elmidae larvae (N.I.W.R. type 6)	12	4	2	3	—	—	1	2	—	—
Helodidae larvae nr. *Hydrosiphon* sp.	—	—	—	—	—	—	1	—	—	—
DIPTERA										
Tipulidae sp. 1	—	2	—	—	—	3	3	2	3	3
Tipulidae sp. 4	—	2	1	—	—	1	1	1	2	3
Tipulidae sp. 6	—	—	—	—	—	—	—	1	—	—
Tipulidae sp. 8	—	—	—	—	1	—	—	2	—	—
Simulium spp.	51	64	12	9	72	2	25	—	26	12
Pentaneura spp.	5	—	15	18	10	2	—	14	—	5
Pentaneura sp. 1	—	—	—	—	—	2	—	—	—	—
Pentaneura sp. 7	7	35	33	—	—	3	8	—	2	—
Orthocladinae spp.	28	—	—	20	—	—	—	—	—	—
Orthocladinae sp. 1	4	5	5	—	10	5	2	10	17	13
Orthocladinae sp. 7	2	4	6	4	2	18	20	14	4	14
Orthocladinae sp. 11	2	—	2	2	3	3	4	5	1	—
Orthocladinae sp. 12	—	—	—	—	—	—	16	—	—	—
Orthocladinae sp. 13	2	3	2	3	2	—	—	—	—	1
Corynoneura sp. 1	—	—	20	—	—	—	—	—	—	—
Chironominae sp. 5	—	—	—	—	—	2	—	—	—	—
Tanytarsus sp. 4	4	23	55	7	6	42	82	40	55	102
Tanytarsus sp. 8	—	2	2	—	2	—	—	—	15	—
Tanytarsus sp. 13	—	—	—	—	—	7	—	—	—	—
Tanytarsus sp. 14	38	15	15	4	34	—	40	3	18	5
Tanytarsus sp. 15	2	21	15	8	—	68	320	61	170	218
Tanytarsus sp. 17	3	6	22	—	1	2	12	6	—	—
Bezzia sp.	2	—	3	18	—	—	2	—	1	—
Atrichopogon sp.	2	—	—	—	—	—	—	—	3	—
Tabanidae sp. 2	2	2	—	—	—	—	—	—	—	—

TABLE II (Continued)

	Station 9 - Open					Station 8 - Shaded				
	1	2	3	4	5	1	2	3	4	5
DIPTERA (Cont.)										
Rhagionidae larvae (nr. *Atherix* sp.)										
Empididae sp. 1	8	3	2	—	—	1	2	—	—	2
Empididae sp. 2	—	—	—	—	6	1	—	2	1	—
MOLLUSCA										
Burnupia sp.	2	—	—	—	—	13	2	—	2	2
TOTAL NUMBER OF ORGANISMS	592	570	576	458	540	315	743	344	678	541

Station 10 (Open) - Sawmill Creek, and Station 6 (Shaded) - Hislops Creek

These stations were on separate streams, separated by a distance of about 25 kilometres. In this respect they were the least comparable of the three pairs of sampling stations.

TABLE III

The quantitative sampling results from station 10 *(open) - Sawmill creek, and station* 6 *(shaded) - Hislops creek.*

The figures given represent the number of individuals per 900 sq. cm.

	Station 10 - Open					Station 6 - Shaded				
	1	2	3	4	5	1	2	3	4	5
TURBELLARIA										
Planaria sp.	—	—	—	1	—	11	21	3	1	10
NEMERTEA										
Prostoma sp.	—	1	—	—	—	—	—	—	—	—
NEMATODA	—	—	—	—	1	—	—	—	—	—
OSTRACODA	—	—	—	—	—	84	112	136	45	140
COPEPODA	40	—	—	—	—	—	—	—	—	—
HYDRACARINA	—	24	—	—	32	72	40	24	16	12
PLECOPTERA										
Neoperla spio	11	4	4	—	2	—	—	—	—	—
EPHEMEROPTERA										
Pseudocloeon undescribed sp. det. AGNEW (N.I.W.R. type VAL 1019 R)	14	—	—	—	—	—	—	—	—	—
Baetis harrisoni	176	152	155	132	161	9	10	10	11	25

TABLE III (Continued)

	Station 10 - Open					Station 6 - Shaded				
	1	2	3	4	5	1	2	3	4	5
EPHEMEROPTERA (Cont.)										
? Baetidae undescribed sp. det. AGNEW	—	—	5	1	2	1	—	—	—	—
Caenidae sp. 1	45	51	12	87	47	144	76	79	15	35
Tricorythus discolor	18	10	2	1	18	8	19	4	1	9
Castanophlebia calida BARN.	—	2	—	—	—	—	—	—	—	—
Euthraulus elegans	46	55	41	37	41	9	1	7	—	9
Afronurus harrisoni	2	1	5	8	4	52	20	25	8	5
ODONATA										
Chlorolestes sp.	—	—	—	—	—	—	—	2	—	—
Paragomphus cognatus	9	4	4	11	4	—	—	—	—	—
Aeschna rileyi	2	3	—	2	2	—	—	1	—	—
TRICHOPTERA										
Hydropsyche sp.	21	8	2	4	4	—	—	—	—	—
Cheumatopsyche ? thomasetti	12	34	6	6	10	—	1	—	—	—
Cheumatopsyche ? afra	9	16	3	5	2	4	—	12	5	15
Chimarra spp.	9	—	—	1	4	—	8	2	—	2
Hydroptila undescribed sp. det. SCOTT	—	2	—	—	2	—	—	—	—	—
Hydroptila ? cruciata	—	1	2	—	—	—	—	—	—	—
Orthotrichia sp. 1	—	—	—	—	1	—	1	—	2	—
COLEOPTERA										
Orectogyrus sp.	—	4	—	—	—	—	—	—	—	—
Psephenidae sp.	3	1	—	—	—	1	2	7	4	3
Elmidae larvae (N.I.W.R. type 1)	22	6	—	6	2	—	9	25	1	1
Elmidae larvae (N.I.W.R. type 6)	9	5	19	4	4	113	39	35	17	52
Elmidae adult (N.I.W.R. type V)	—	2	2	4	—	6	2	2	—	2
Elmidae adult (N.I.W.R. type W)	—	2	—	—	—	—	—	—	—	—
Helodidae larva (nr. *Hydrosiphon* sp.)	—	2	—	—	3	—	—	—	—	—
DIPTERA										
Tipulidae sp. 1	12	14	6	28	29	6	—	1	1	1
Tipulidae sp. 4	3	1	1	2	1	1	—	—	—	—
Simulium spp.	180	70	3	6	2	2	1	5	1	69
Pentaneura spp.	1	2	1	4	2	2	—	9	5	2
Pentaneura sp. 7	—	—	4	2	5	—	—	—	—	—
Orthocladinae spp.	—	—	—	80	8	—	—	—	2	—
Orthocladinae sp. 1	3	10	—	2	4	9	—	1	—	1
Orthocladinae sp. 7	—	—	—	—	3	—	—	—	—	—

TABLE III (Continued)

	Station 10 - Open					Station 6 - Shaded				
	1	2	3	4	5	1	2	3	4	5
Orthocladinae sp. 11	—	—	—	2	2	—	—	—	—	—
Orthocladinae sp. 12	1	6	—	—	—	—	—	—	—	—
Orthocladinae sp. 13	3	—	82	15	6	—	—	—	—	—
Orthocladinae sp. 14	—	—	100	47	28	—	—	—	—	—
Orthocladinae sp. 15	—	—	—	—	38	—	—	—	—	—
Orthocladinae sp. 16	—	—	—	—	—	—	1	—	—	—
Corynoneura sp.	—	—	—	—	—	—	1	8	—	4
Chironomini sp. 5	15	12	2	7	2	—	1	—	—	—
Tanytarsini spp.	—	—	—	—	8	—	—	—	—	—
Tanytarsini sp. 1	3	5	—	3	—	—	—	—	—	—
Tanytarsini sp. 4	140	64	114	72	—	9	9	23	6	9
Tanytarsini sp. 14	8	46	50	—	—	1	66	35	16	32
Tanytarsini sp. 15	360	381	254	92	96	2	9	7	1	1
Tanytarsini sp. 17	3	6	—	—	103	—	—	—	—	—
Atrichopogon sp. 1	3	—	—	—	—	—	—	—	1	—
Bezzia sp.	6	—	6	2	1	—	1	—	—	—
Rhagionidae larvae (nr. *Atherix* sp.)	—	—	—	1	—	12	4	10	5	2
Tabanidae sp. 2	8	1	—	1	—	1	—	—	1	1
Empididae sp. 2	—	1	2	—	—	—	—	1	—	—
MOLLUSCA										
Burnupia sp.	—	—	—	—	—	37	3	30	16	10
TOTAL NUMBER OF ORGANISMS	1,197	1,009	887	676	682	596	457	504	181	452

A COMPARISON OF THE SAMPLES TAKEN FROM THE DIRECTLY COMPARABLE OPEN AND SHADED STATIONS

Insufficient samples have been taken for it to be possible to employ rigid numerical criteria to determine the significance of the difference in occurrence of a species in shaded and illuminated reaches. The conclusions drawn are based therefore on criteria which greatly depend on the observers knowledge of each species or group and their relative incidence and consistency of occurrence.

The conclusions drawn are based predominantly on the sampling results recorded in this section (Part II). However, the results of the sampling from stickles recorded in Part I have also been considered.

The species listed in the tables can be divided into three categories.

A Species that were found only in low incidences or inconsistently in the samples and therefore whose relative occurrence in shaded and illuminated reaches of the stream could not be assessed.

B Species which occurred consistently or in sufficiently high incidences to indicate a "preference" for either shaded or illuminated reaches, had one been present, but which appeared unaffected in their distribution by these factors

C Species which, like group B, occurred consistently or in large numbers but which did appear to be influenced in their distribution by shade or illumination.

The majority of species fall into group A. Only groups B and C will be listed and discussed below

GROUP B

1 Nematoda and Hydracarina

2 Caenidae sp. 1

3 *Aeschna rileyi*

4 Elmidae spp.

Although the Coleoptera as a whole fall into group A, the Elmidae occurred consistently and in large numbers.

5 Simuliidae

Despite ZAHAR'S (1951) observation "that *Simulium* larvae were absent from streams closely overhung by the foliage of trees", very high incidences occurred consistently in both shaded and illuminated reaches.

6 Chironomidae

The group as a whole indicated no "preference" for either shaded or illuminated reaches. However, the occurrence of individual species was often too infrequent to be assessed. Only Orthocladinae sp. 14 appeared influenced by these factors

7 Ceratopogonidae

(*Atrichopogon* spp. and *Bezzia* spp.)

GROUP C

This group may be further sub-divided into:

(i) those species which occurred in greater numbers in shaded reaches, and

(ii) those occurring in greater numbers in illuminated reaches.

(The incidences at the shaded and illuminated stations of species included in this group on a basis of the sampling recorded in this section (Part II) is depicted in the histograms in Fig. 1).

(i) Species occurring in greater numbers in shaded reaches:

1 *Centroptilum sudafricanum*

In the case of this species the indications are drawn from the results of the general survey (Part I) in which it was absent from samples taken from the open stations 13 and 15, but present, often

in high incidences, at the shaded Stations 4, 11 and 12, and the moderately shaded Station 17. It was not found at all in the investigation described in this section (II).

2 *Tricorythus discolor* (Fig. 1)

This was found in low incidences in four samples from Station 1 (open) and in much higher incidences in all samples from Station 2 (shaded). It was found in only one sample from Station 9 (open) and in all from Station 8 (shaded), again with the incidences at the latter being considerably higher. No obvious preference was indicated by the samples taken from Stations 10 and 6 as it appeared consistently in all.

3 *Afronurus harrisoni* (Fig. 1)

This species was taken in low incidences from the two samples at Station 2 (shaded), but was not found at all at Station 1 (open). It was present in all samples from Station 8 (shaded) and only a few were taken in one sample from Station 9 (open). It was found in all samples from Stations 10 and 6 (shaded), but in larger numbers from the latter.

4 *Adenophlebia auriculata* and *Castanophlebia calida*

From the general survey alone it can be seen that both these species were found predominantly in small heavily shaded streams. They were not found at all in the investigation reported here (Part II).

5 *Burnupia* sp. 1 (Fig. 1)

The results indicate a markedly higher occurrence in shaded reaches.

(ii) Species occurring in greater numbers in illuminated reaches:

1 *Neoperla spio* (Fig. 1)

It was recorded in low incidences only from the open stations of the stream pairs; but in the general survey it occurred at both open and shaded stations.

2 *Baetis harrisoni* (Fig. 1)

This was found in all samples and often in large numbers. No light shade preferences were indicated by the samples from Stations 1 and 2. The numbers taken from Stations 8 and 9, and Stations 10 and 6, indicate clear cut preferences for open regions. This is further confirmed by the results of the general survey, in which the species were not taken from the shaded stations 4, 11 and 12, but occurred in large numbers at the open stations 5 and 13. The moderately shaded station 17, however, contained an intermediate number of specimens.

3 *Centroptilum excisum* (Fig. 1)

This was not found at all in the general survey. It occurred in low numbers in four samples, two from Station 1 (open) and two from Station 9, (open).

4 *Euthraulus elegans* (Fig. 1)

This species appeared to be confined to low lying streams and reaches, as it was not collected above an altitude of 800 m, it therefore did not appear at Stations 1 and 2. The incidence was higher at Station 8 (open) than at Station 9 (shaded) although it was collected in all samples. It was also collected in all samples from Stations 10 (open) and 6 (shaded) with the larger numbers from Station 10. In the general survey it was only taken from the moderately shaded Station 17.

5 Odonata

This as a group is classified under Group A, with three exceptions:

(*a*) *Paragomphus cognatus* (Fig. 1)

This species was not found at Stations 1 and 2; was found in higher incidences at Station 9 (open) than 8 (shaded), and in very markedly higher numbers at Station 10 (open) in which it occurred in all samples as opposed to none from Station 6 (shaded).

(*b*) *Zygonyx* sp. 1 (Fig. 1)

Was found in low incidences in a few samples at each station. At Station 1 (open) and Station 2 (shaded) it was taken from only one sample from Station 1; at Stations 9 (open) and 8 (shaded) from a few samples from Station 9 and only one from Station 8. It was not collected from Stations 10 and 6, and in the general survey (Part I), only from Station 13 (open).

(*c*) *Aeschna rileyi*

Has been placed in Section B.

6 *Cheumatopsyche* ? afra and *Cheumatopsyche* ? *thomasetti* (Fig. 1)

Were both found in higher incidences, and more consistently at the open stations of the pairs 9 and 8, and 10 and 6. The occurrence of both species at Stations 1 and 2, and in the general survey, was too nominal to enable conclusions to be drawn.

7 *Hydropsyche* sp. (Fig. 1)

Was taken consistently, and in large numbers only from Station 10 (open).

8 *Hydroptila* ? *cruciata* (Fig. 1)

Showed very significant open region "preferences", and was collected exclusively at the open stations.

9 *Orthocladinae* sp. 14 (Fig. 1)

This was the only species of Chironomidae which manifested any lightshade distribution. It was found in high incidences at the open Stations 1 and 10, but in low incidences, and not at all, at the corresponding shaded stations 2 and 6 respectively.

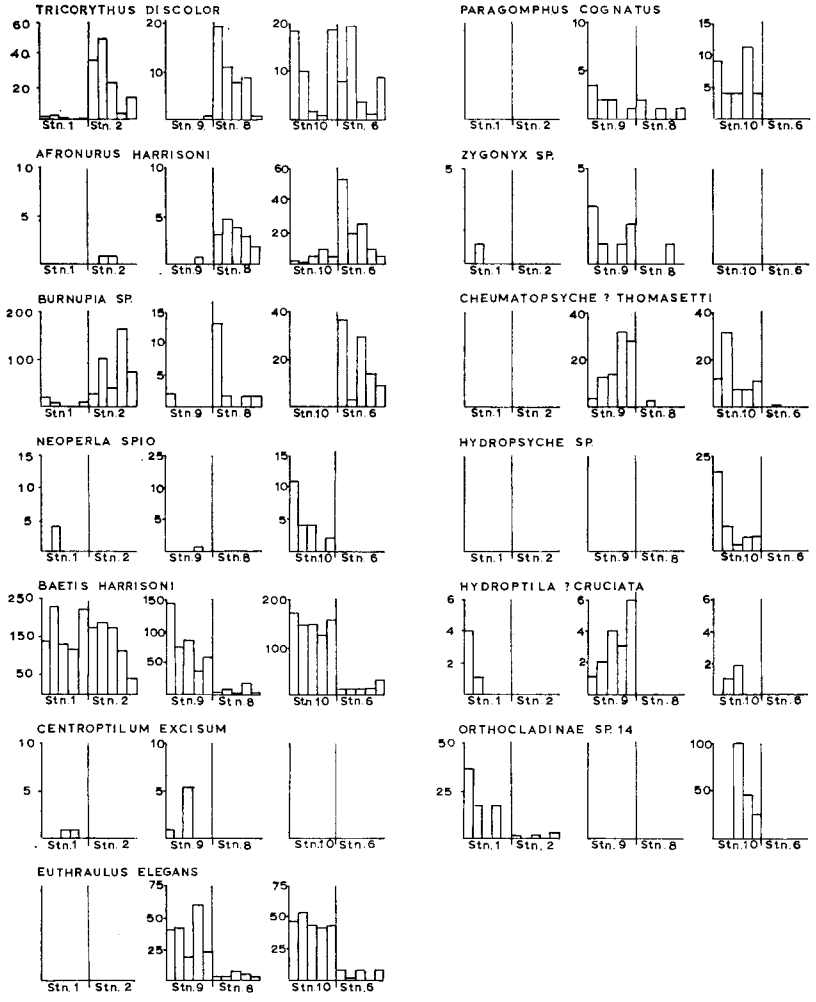

Fig. 1. The incidences of various species at the comparable open and shaded stations. (Stns. 1 (open) & 2 (shaded); Stns. 9 (open) & 8 (shaded); Stns. 10 (open) & 6 (shaded).

The effect of shade and illumination on population densitys

Population density is taken here as the total number of organisms per sample. In the following comparison (Table IV) of the total number of organisms from shaded and exposed reaches of stickles, the figures given represent the density of the fauna per 900 sq. c.

Table IV

The total number of organisms per sample taken from the shaded and exposed sampling stations.

	Station 1 (open)					Station 2 (shaded)				
Sample no.	1	2	3	4	5	1	2	3	4	5
Total per 900 sq. cm	559	545	397	694	727	823	788	677	674	348
Total			2,922					3,310		
Mean			584					662		

	Station 9 (open)					Station 8 (shaded)				
Sample no.	1	2	3	4	5	1	2	3	4	5
Total per 900 sq. cm	592	570	576	458	540	315	743	344	678	541
Total			2,736					2,621		
Mean			547					524		

	Station 10 (open)					Station 6 (shaded)				
Sample no.	1	2	3	4	5	1	2	3	4	5
Total per 900 sq. cm	1,197	1,009	887	676	682	596	457	504	181	452
Total			4,451					2,190		
Mean			890					438		

Discussion of results

A discussion of the factors operative in determining the results in each case is not within the scope of this survey. Both direct and indirect factors could be operating individually or simultaneously and only detailed investigation of individual species would elucidate the exact factors in each case. One may assume, however, that in the case of the trichopteran *Hydroptila* ? *cruciata*, a species found predominantly in open reaches, its distribution is dependent on the long algal filaments used in the construction of its larval and pupal cases.

Harrison & Elsworth (1958) compared the faunas of a shaded tributary of the Berg river (Western Cape Province) and a physically

similar open reach on the main Berg river at the same altitude. Only in the case of the mayfly *Baetis harrisoni* did this investigation substantiate their results, this species being found in greater numbers in open reaches in both cases. *Cheumatopsyche afra* BARN. (Trichoptera), Chironomidae (mainly Orthocladinae) and *Simulium* larvae were found by HARRISON & ELSWORTH in higher incidences in shaded streams, whereas in this survey *Cheumatopsyche* ? *afra* occurred in greater numbers in the open reaches and there were no obvious differences in the distribution of Chironomidae and Simuliidae.

It appears from the results of Table IV that, when comparing the totals for organisms collected at Stations 1 and 2, and 7 and 8, that population density is unaffected by the factors of shade or illumination. Although a comparison of the totals from Stations 10 and 6 indicate that the density at the open station (10) is markedly greater than that at the station (6), these results cannot be considered as the stations are situated on separate streams.

It can be concluded that although certain species appear influenced in their distribution by the factors of shade and direct illumination, the population density is minimally affected and there is no overall effect on any group or family.

SUMMARY

During the survey reported in Part I, it became apparent that vegetational shading affected the incidences of certain species. The extent to which the distribution of stream fauna is influenced by direct or indirect consequences of shade or illumination was examined and an attempt was made to determine which species or groups are affected.

Three pairs of comparable sampling stations (stickles) were selected on the basis of their physical similarity, one of each pair being shaded and the other illuminated. Samples taken from these stations were compared and species found predominantly in shaded or exposed reaches were assessed.

Although certain species appeared influenced in their distribution, it appears that the population density is minimally affected and there is no overall effect on any group or family.

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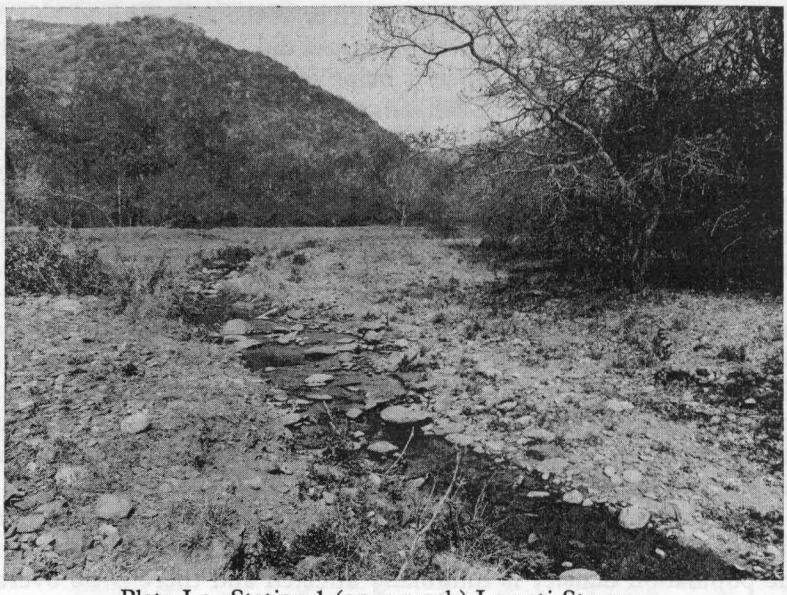

Plate I a. Station 1 (open reach) Lomati Stream.

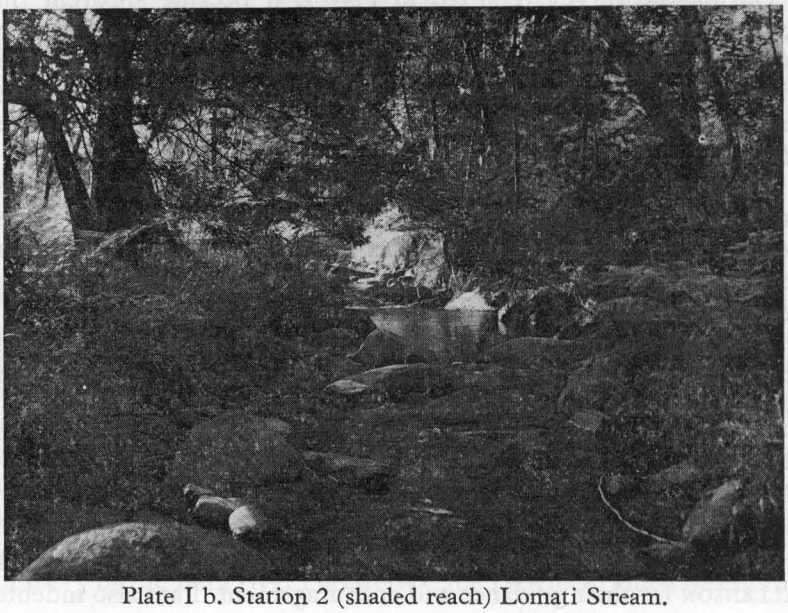

Plate I b. Station 2 (shaded reach) Lomati Stream.

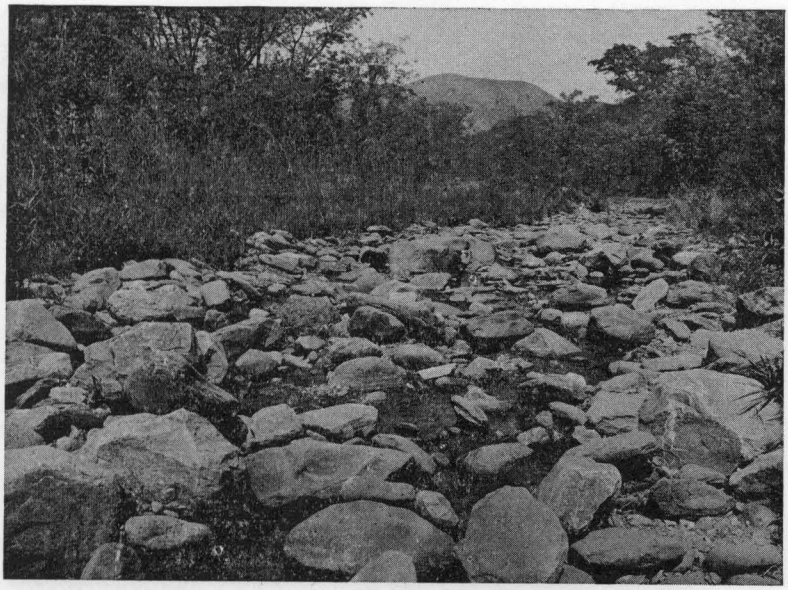

Plate II a. Station 9 (open reach) Concession Creek.

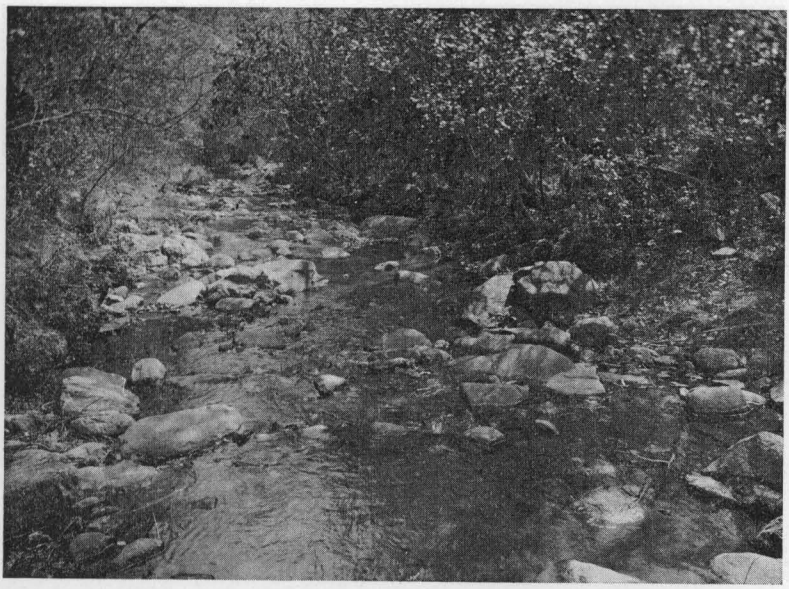

Plate II b. Station 8 (shaded reach) Concession Creek.

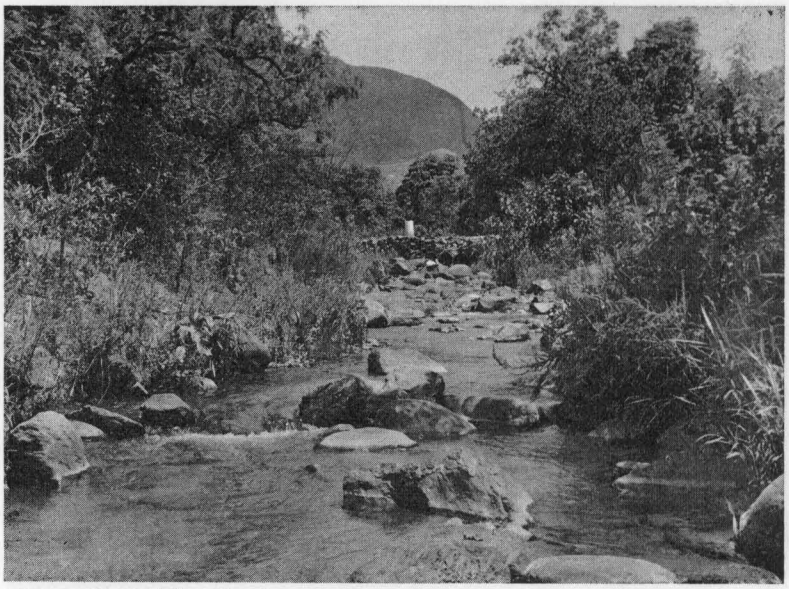

Plate III a. Station 10 (open reach) Sawmill Creek.

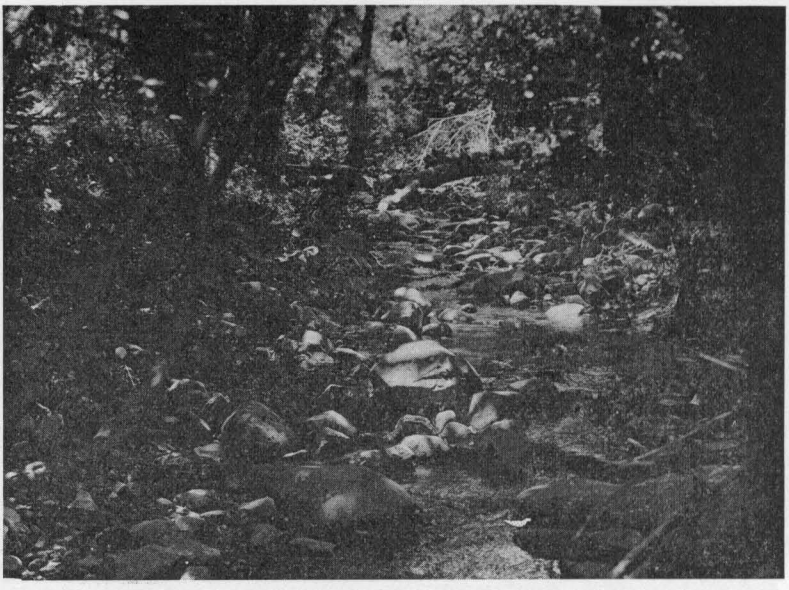

Plate III b. Station 6 (shaded reach) Hislops Creek.

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