Macroinvertebrates in the catchment streams of Lake Naivasha, Kenya

Peter C. BARNARD (1) and Jeremy BIGGS (2)

ABSTRACT

Samples of macroinvertebrates were collected from the catchment streams of Lake Naivasha, Kenya, and 64 species were recorded. The species richness was similar to that of a temperate stream and was less than has been reported in some other studies on tropical streams. The fauna of the River Gilgil was studied in more detail, the community being dominated by Ephemeroptera. Eight mayfly species were recorded along a 40 km stretch, with clear differences in faunal composition along the length of the river. Aquatic plants were scarce, and in the lower reaches of the river most of the macroinvertebrates were found in trailing terrestrial vegetation.

KEY WORDS : Aquatic insects — Macroinvertebrates — Tropical environment — Rivers — Kenya.

RÉSUMÉ

MACRO-INVERTÉBRÉS DES RIVIÈRES DU BASSIN DU LAC NAIVASHA, KENYA

Les macro-invertébrés ont été échantillonnés sur des rivières du bassin du lac Naivasha; 64 espèces ont été récoltées. La richesse spécifique est semblable à celle d'un cours d'eau tempéré et moindre que celle signalée au cours d'autres études réalisées en milieu tropical. La faune de la rivière Gilgil a été étudiée plus en détail, les Éphéméroptères dominaient la communauté; huit espèces ont été récoltées le long d'un bief de 40 km où des différences de composition faunistique ont été mises en évidence. Les plantes aquatiques étaient rares et, dans la partie aval, la plupart des macro-invertébrés ont été récoltés dans la végétation terrestre immergée et traînant dans l'eau.

MOTS-CLÉS : Insectes aquatiques — Macro-invertébrés — Environnement tropical — Rivières — Kenya.

---

(1) *Department of Entomology, British Museum (Natural History), Cromwell Road, London SW7 5BD, UK.*
(2) *Royal Holloway College, University of London, Englefield Green, Surrey TW20 9TY, UK.*
Present adress: c/o Hamlet, Denton Green, Cuddesdon, Oxfordshire OX9 9JD, UK.

1. INTRODUCTION

Although it is generally observed that there is an increase in species richness from the temperate to the tropical zone, MacArthur (1972), following observations made by Patrick (1966), suggested that the numbers of species of macroinvertebrates and algae in tropical rivers was not significantly greater than that observed in temperate rivers. Although a number of studies have been made that are relevant to this hypothesis (for example, Van Someren, 1952; Hynes and Williams, 1962; Illies, 1969; Green, 1970; Williams and Hynes, 1971; Bishop, 1973; Stout and Vandemeer, 1975; Fernando, 1984, and Nwadiaro, 1984), few have reported that tropical rivers clearly show a greater species richness than temperate rivers.

Illies (1969), summarising work on the rivers of the Amazon Basin, reported high taxonomic richness in lowland rivers but not in upland streams, the plecopteran fauna in particular comprising few species in the uplands. Green (1970) showed that there was greater species richness in the streams of the Mato Grosso, Central Brazil, when compared with European streams and Bishop (1973), reporting a two year study of the River Sungai Gombak in Malaysia, found 44 species of Ephemeroptera and at least 79 species of Trichoptera in a stream less than 50 km long. Stout and Vandemeer (1975), who studied a series of streams in North and South America, found that the lower the latitude of the stream the greater the number of invertebrate species present in it, the increase being particularly apparent amongst Ephemeroptera and Trichoptera.

Other studies, however, do not indicate a significantly greater species richness in tropical streams. This fact has prompted us to present further data on the macroinvertebrates of the catchment streams of Lake Naivasha, Kenya, in order to add to the information available with which to test MacArthur's original hypothesis. Our observations also provide further information on the Kenyan macroinvertebrate fauna.

2. THE CATCHMENT OF LAKE NAIVASHA

Lake Naivasha is located northwest of Nairobi at an altitude of 1 890 m in the Eastern Rift Valley of Kenya (0°45′ S, 36°20′ E). The Naivasha Basin is bounded by the Aberdare Mountains to the east and the Mau Escarpment to the west. About 90 % of the discharge into Lake Naivasha is from the Malewa River (1 730 km² catchment), which receives its water from the Kinangop Plateau and the Aberdares. Much of the rest of the water flowing into the lake comes from the River Gilgil (420 km² catchment), which drains the Bahati Highlands to the north of the Elmenteita-Nakuru basin, though much of the Gilgil's water is abstracted for irrigation.

The catchment of Lake Naivasha is volcanically active and the rocks of the area consist of an assemblage of acidic and basic lavas (Litterick *et al.*, 1979). The climate of the region is warm and, although rainfall near Lake Naivasha has a muted bimodality with a main pulse in April and May and a minor pulse in November, the pattern is complicated by rainfall in the surrounding uplands. The catchment is highly modified by human activity, being used for cattle ranching, vegetable growing and dairy farming.

3. METHODS

Macroinvertebrates were collected from streams in the catchment of Lake Naivasha during December 1982 and January 1983; the list of all 13 sites visited is given in Table I, and their positions are indicated on the map in fig. 1. All sites were visited at least once, with more frequent observations being made at six sites on the River Gilgil. Sites 1-5 on the Gilgil ranged in altitude from 1 600 m to 2 100 m, with site 6 at 2 500 m. Sites 7-9 on the Malewa were at 1 900 m, sites 10 and 11 at 2 300 m, site 12 at 2 400 m and site 13 at 2 600 m.

During the initial survey of the catchment, macroinvertebrates were collected by kick- and sweep-sampling with a standard pond net, separated from detritus in white trays and preserved in 4 % formaldehyde solution before identification. Following the initial survey more detailed observations on the distribution and abundance of macroinvertebra-

Table I

List of collecting sites on the Naivasha catchment streams (U.T.M. Grid, Zone 37)

Stations de prélèvements dans le bassin du lac Naivasha, et position géographique dans la grille

Site		Grid ref.
1	River Gilgil, North Lake Road	BK 058311
2	River Gilgil, Naivasha-Gilgil Road	BK 060365
3	River Gilgil, Kenyatta Polo Ground	BK 060407
4	River Malewa, Naivasha-Gilgil Road	BK 103265
5	River Malewa, Marula Vet. Station	BK 120278
6	River Malewa, south of Melawa	BK 134306
7	River Malewa, Old Wanjohi Road	BK 121646
8	River Murindati, Kipipiri Road	BK 045457
9	River Murindati, Hall's Road	BK 008567
10	River Murindati, near Tumaini	AK 974712
11	River Turasha, Wishipon	BK 207369
12	River Ol Kalou, Old Wanjohi Road	BK 102642
13	River Kinja, Aberdares	BK 355360

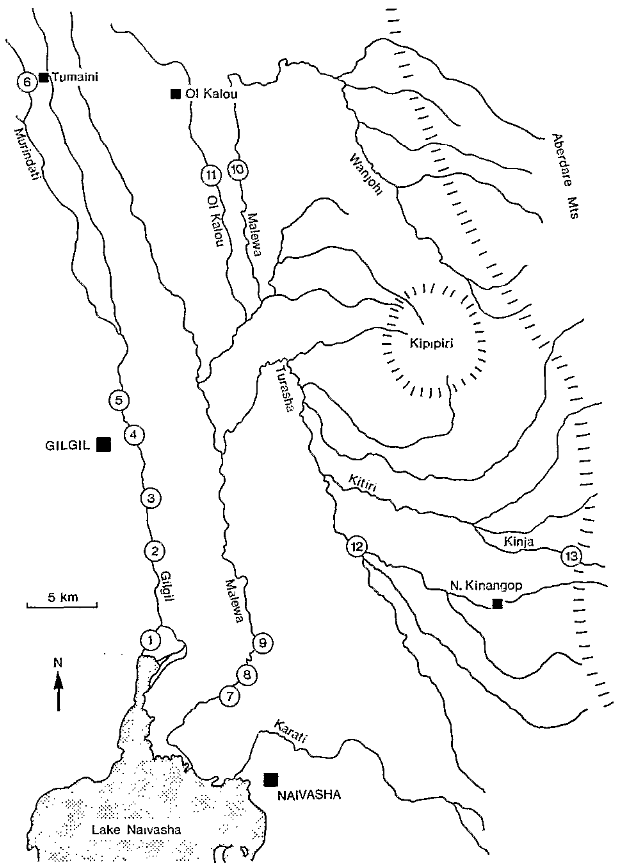

FIG. 1. — Map of the Lake Naivasha catchment, showing the 13 sampling sites. *Bassin du lac Naivasha et stations de prélèvement*

tes were made at six sites on the River Gilgil (sites 1-6 in fig. 1). At the four lower sites on the Gilgil it quickly became apparent that most macroinvertebrates were found in terrestrial vegetation trailing in the water. For this reason sampling concentrated on the fauna of this micro-habitat in the lower reaches of the river. At the upper two sites conventional benthic samples were taken from riffles with a Surber sampler.

In order to collect samples of macroinvertebrates from trailing vegetation the plant material present in a volume of about 30 cm^3 was clipped at water level and collected in a Surber sampler held immediately downstream of the vegetation to be removed. Invertebrates were separated from trailing vegetation and detritus, and preserved in 4% formaldehyde solution before counting and identification. Because of the paucity of trailing vegetation, sample sites were selected rather than being chosen at random. Brief observations of the benthic fauna of

TABLE II

Physical and chemical features of the River Gilgil
Données sur l'environment aux stations sur la rivière Gilgil

Site	Water temperature (°C)	Water velocity ($m\ s^{-1}$)	Conductivity ($\mu S\ cm^{-1}$)	Dissolved oxygen concentration ($mg\ l^{-1}$)	Stream width (m)
1	18.3	0.27	67.5	6.5	4.0
2	16.3	-	60.6	7.3	3.5
3	18.0	-	63.6	6.9	3.7
4	-	0.29	-	-	4.0
5	14.8	0.25	69.0	7.3	4.0
6	13.7	0.26	72.0	7.5	1.5

sandy substrates were also made on the lower reaches of the Gilgil at the same time. At the two upper sites on the Gilgil benthic samples were collected with a Surber sampler, the sites again being selected and not chosen at random. Because of the differences in sampling methods, comparisons of the numbers of macroinvertebrates have been made in terms of relative abundance. Water temperature, conductivity and dissolved oxygen concentration were measured using a portable meter. Current velocity was estimated by recording the time taken for an orange to travel over a defined length of stream (see Table II).

In order to relate invertebrate abundance to the abundance of trailing terrestrial plants the vegetation collected was oven dried at 100 °C and weighed to the nearest 0.1 g.

Most of the material collected is preserved in the British Museum (Natural History), but voucher specimens have been deposited in the National Museum of Kenya, Nairobi.

4. RESULTS AND DISCUSSION

Fig. 1 shows the sites from which macroinvertebrates were collected and a list of the taxa recorded is given in Table III; in this table 'sp.' indicates a single species in that group. Sixty-four taxa were recorded from the catchment but, as the fauna is poorly known, it has been possible to identify relatively few taxa to species level, and the significance of their occurrence can only be discussed in general terms. This difficulty in identifying the fauna is of course a widespread problem in tropical hydrobiology, and emphasies the need for more taxonomic studies in these regions.

TABLE III

Check-list of macroinvertebrates of the Naivasha catchment streams
Liste des macro-invertébrés collectés dans les rivières du bassin du lac Naivasha

TRICLADIDA 1 sp. indet.

OLIGOCHAETA 1 sp. indet.

HIRUDINEA 1 sp. indet.

CRUSTACEA (DECAPODA)
Potamidae:
Potamonautes granviki (Colosi)

INSECTA: EPHEMEROPTERA
Baetidae:
Baetis sp.
Centroptilum montanum Kimmins
Centroptilum sp. A
Centroptilum sp. B
Pseudocloeon sp. Crass
Cloeon perkinsi Barnard
Centroptiloides sp.

Caenidae:
Afrocaenis ?major Gillies
Caenidae sp.
?Afrocaenis sp.

Heptageniidae:
Afronurus sp.

Leptophlebiidae:
Choroterpes (Euthraulus) sp.

ODONATA
Aeshnidae sp.
Coenagrionidae sp. A
Coenagrionidae sp. B
Gomphidae sp.
Libellulidae sp.

HEMIPTERA
Belostomatidae: Diplonychus wittei (Poisson)

Corixidae:
Micronecta sp. (immatures)
Micronecta ?piccanin Hutchinson
Micronecta ?scutellaris (Stål)
Tropocorixa sp.

Helotrephidae: Esakiella sp.
Nepidae: Laccotrephes sp.
Notonectidae: Anisops sp.
Pleidae: Paraplea sp.

COLEOPTERA
Dytiscidae:
Potamonectes abyssinicus Sharp
Yola frontalis Régimbart
Hydaticus galla Guérin
Hydaticus jucundus Reiche
Guignotus sordidus Sharp
Agabus raffrayi Sharp

Elmidae: ?Pseudomidolia sp. (larvae)
Gyrinidae:
Dineutus staudingeri Ochs
Aulonogyrus sp.
?Aulonogyrus sp. (larvae)
?Orectogyrus sp. (larvae)

Hydrophilidae: Helochares sp.
Scirtidae sp. (larvae)

TRICHOPTERA
Ecnomidae:
Ecnomus thomasseti Mosely
Ecnomus sp.

Hydropsychidae:
Cheumatopsyche sp. A
Cheumatopsyche sp. B
Cheumatopsyche sp. C
Cheumatopsyche sp. D
Hydropsyche sp.

Hydroptilidae sp.
Lepidostomatidae:
Goerodes sp. A
Goerodes sp. B

Leptoceridae:
Leptocerina ramosa pinheyi Kimmins
sp. A
sp. B
sp. C
sp. D

DIPTERA
Ceratopogonidae spp.
Chironomidae spp.
Empididae : Wiedemannia sp.
Ephydridae spp.
Simuliidae spp.
Tipulidae spp.

4.1. The invertebrates of the Naivasha catchment

Most of the identified species of Coleoptera and Hemiptera are common and widespread in eastern Africa, or through the Afrotropical region as a whole. Most of the Diptera and Odonata could only be identified to family level, thus precluding any useful discussion of their significance.

Within the Trichoptera, the occurrence of four species of *Cheumatopsyche* and two of *Goerodes* is to be expected as these are often the dominant groups in Afrotropical running waters. Although one species of *Ecnomus* could not be identified, the other was clearly *E. thomasseti* Mosely, which was also collected from Lake Naivasha itself, along with adults of the same species (BARNARD and CLARK, 1986); this is apparently the commonest species of *Ecnomus* in southern, central and east Africa. Four of the five species of Leptoceridae could not be reliably identified to genus, which is a reflection of the poor state of the larval taxonomy in the African members of this family. However, *Leptocerina ramosa pinheyi* was easily recognised from HICKIN's (1956) description, and by comparison with HICKIN's original material, now in the British Museum (Natural History). This subspecies was described from fast-flowing streams in Uganda.

More information is available on the Ephemeroptera, and the following notes were all provided by Dr. M. T. GILLIES (pers. comm.). Amongst the Baetidae, one species of *Centroptilum* closely resembles sp. no. 3 of DEMOULIN (1964), but a hind wing dissected out from a mature nymph had a double spur, showing the species to be *C. montanum* Kimmins, known from Mt Elgon and from near Lake Kivu. Of the two other species of *Centroptilum*, one somewhat resembles *C. marlieri* Demoulin from Zaïre and also *Acentrella* sp. A of KIMMINS (1955) from Malawi, yet the dorsal spines are quite different from either. The other species closely resembles sp. no. 2 of DEMOULIN (1964) from Mt Elgon, except that the 3rd labial segment is larger, and the femora lack the fringe of fine hairs. Although currently regarded as belonging to *Centroptilum*, this group of species should probably be regarded as distinct.

The *Pseudocloeon* is apparently the same as the unnamed species described by CRASS (1947) from Natal; *Cloeon perkinsi* Barnard is the most widespread and common of the African *Cloeon*.

Two of the Caenidae spp. are difficult to determine, but the third closely resembles *Afrocaenis major* Gillies from Tanzania and Ethiopia. The spines on the fore femur are slightly different, but it may nevertheless be conspecific. It is certainly distinct from an unnamed species known from Nanyuki on Mt Kenya (M. T. GILLIES, pers. comm.).

4.2. **Taxonomic richness in the Naivasha catchment**

It is apparent that the number of species in streams in the Naivasha catchment is relatively low and does not differ greatly from that to be expected in temperate streams of a similar size. For example, in a survey of small acid streams in southern England, TOWNSEND *et al.* (1983) found between 18 and 57 species at individual sites, and 124 species at all sites combined, in the headwater streams of the Rivers Medway and Sussex Ouse. In a survey of rivers throughout Great Britain, WRIGHT *et al.* (1984) reported numbers of species similar to those recorded in the catchment of Lake Naivasha.

The number of species recorded in the catchment of Lake Naivasha was also similar to that recorded in other African streams. For example, only eight species of Ephemeroptera were recorded from the Gilgil, a number similar to that found by HYNES (1975), working on the riffle fauna of the Pawmpawm River in Ghana, who recorded six species of Ephemeroptera, although undetermined species of *Centroptilum, Centroptiloides* and *Baetis* may also have been present. HYNES did not suggest that the number of other species was high. VAN SOMEREN (1952) also noted that species richness was low in the Sagana River in Kenya, the macroinvertebrate fauna in areas of gravel and stone being dominated by *Baetis* sp. and *Simulium* sp. In contrast, 44 species of Ephemeroptera were recorded by BISHOP (1973) in the River Sungai Gombak in Malaysia, this high number being attributed to the wide variety of micro-habitats present.

A number of factors may have contributed to the low number of species in the catchment streams of Lake Naivasha. It has been observed in studies of streams in Great Britain that, in general, the larger a river the greater the number of species found in it (WRIGHT *et al.*, 1984), it usually being assumed that in a larger river a greater number of micro-habitats may be found. In this study, all sites that were sampled were relatively small (for example, the channel width in the River Gilgil was between 1.5 m and 6.0 m and the depth of water up to 50 cm) and might be expected to contain a small number of micro-habitats. In addition, rainfall in the catchment, and consequently flow, is seasonal and may lead to a rather unstable environment in which only those species able to tolerate periods of reduced flow (or complete drying of streams) are able to survive. Although the limited sampling period in December and January might suggest an under-sampling bias, this short period actually covered the extremes from the end of the November rains to the beginning of the dry season, so it is likely that the samples are reasonably representative.

At the lower three sites on the River Gilgil the stream bed was predominantly unstable sand and no submerged vascular plants were found, probably as a result of the turbidity of the water. In addition, the channel profile at the lower sites was very regular, offering little diversity in benthic substrates, although at the upper sites mosses, which supported a variety of macroinvertebrates, were present on stony substrates. The sand at the lower sites supported very small numbers of oligochaetes and chironomids, and most invertebrates were found in terrestrial vegetation trailing in the water. Because of the instability of the substrates and the relatively small quantities of terrestrial trailing vegetation present, only a small proportion of the stream was suitable for colonisation by macroinvertebrates.

4.3. **Distribution and relative abundance of major macroinvertebrate groups**

The River Gilgil was selected for more detailed study as a representative example of the streams in the catchment of Lake Naivasha; fig. 2 shows the relative abundance of major macroinvertebrate groups in the river, recorded as numbers of individuals. At the first four sites (1-4) the results refer to macroinvertebrates collected from trailing vegeta-

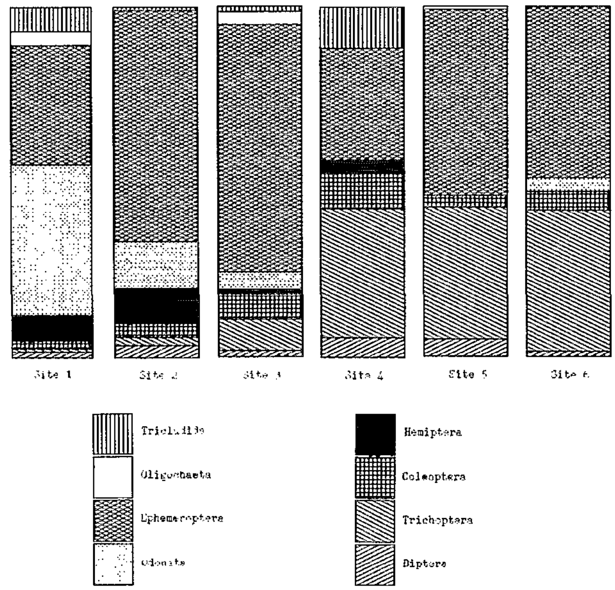

FIG. 2. — The relative abundance of the major invertebrate groups collected at the six sampling sites on the River Gilgil, recorded as numbers of individuals. *Abondance relative, en nombre d'individus, des principaux groupes d'invertébrés récoltés aux 6 stations de la rivière Gilgil*

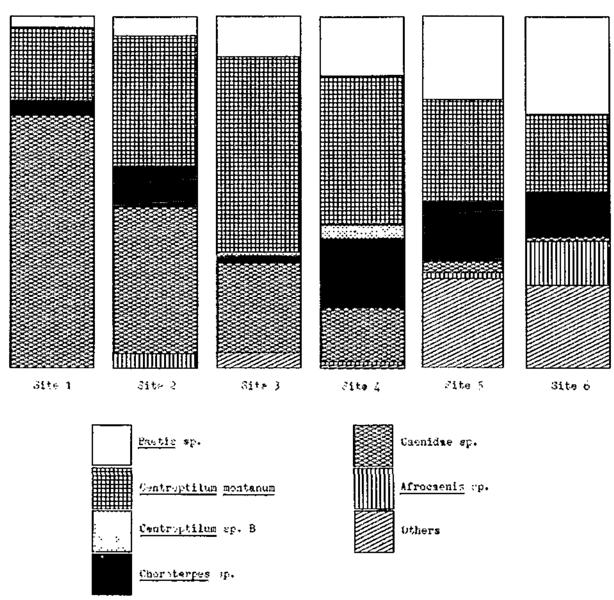

FIG. 3. — The relative abundance of species of Ephemeroptera collected at the six sampling sites on the River Gilgil, recorded as numbers of individuals. *Abondance relative des Ephéméroptères, en nombre d'individus, récoltés aux 6 stations de la rivière Gilgil*

tion and at the upper two sites (5, 6) to macroinvertebrates collected from benthic substrates. The trailing vegetation micro-habitat, in which most macroinvertebrates were found in the lower four reaches of the river, was dominated by Ephemeroptera, other groups being of varying importance. Ephemeroptera comprised between 32 % and 70 % of the fauna at the lower sites, only Odonata approaching them in abundance amongst trailing vegetation. *Centroptilum montanum* was the most abundant Ephemeropteran at all except one site where trailing vegetation was sampled. Ephemeroptera were also the most important component of the fauna on stony substrates at the two upper sites on the Gilgil.

Only Trichoptera approached the importance of Ephemeroptera, with a relative abundance increasing from about 1 % of the fauna to about 40 % of the fauna from the lowest to the uppermost site on the Gilgil. Other groups were irregularly distributed throughout the length of the Gilgil. Tricladida, Odonata and Hemiptera were restricted to the lower reaches of the river, occurring mainly in trailing vegetation. Oligochaeta, Coleoptera and Diptera were found throughout the river but comprised a relatively small proportion of the fauna. The low numbers of Oligochaeta and Diptera suggest that trailing vegetation presents an unsuitable habitat for these groups. No Mollusca or Hirudinea were recorded in the River Gilgil.

HYNES and WILLIAMS (1962) and WILLIAMS and HYNES (1971) have also reported streams in Kenya with faunas dominated by Ephemeroptera. In the former study it was noted that *Baetis* and *Centroptilum* made up between 37.5 % and 69.5 % of the fauna in the River Manafwa, proportions very similar to those found in the River Gilgil. In contrast to the Gilgil, however, Diptera were generally the second most abundant group in this river, comprising up to 40 % of the fauna at any site, whereas Trichoptera did not comprise more than 6.6 % of the fauna at any site. HYNES (1975) found that Chironomidae made up 35 % of the riffle fauna, also finding that Ephemeroptera comprised up to 35 % of the fauna.

The Ephemeropteran fauna of the River Gilgil was dominated by four species, *Baetis* sp., *Centroptilum montanum*, the leptophlebiid *Choroterpes* sp. and Caenidae sp. A, which were recorded at all sites. Four further species, *Afrocaenis* sp., *Centroptilum* sp. B, *Pseudocloeon* sp. and *Afronurus* sp. were recorded at some sites. Fig. 3 shows the relative abundance of these species at the six sites on the Gilgil, recorded as numbers of individuals. Two taxa show a clear relationship with increasing altitude, which may have influenced Ephemeropteran distribution either through changes in substrate (although water velocities at the upper sites were little different to those at the lower sites) or through changes in water temperature (see Table II). Caenidae sp. A was most abundant in the lower reaches of the river, its relative importance declining upstream. *Centroptilum montanum* reached its maximum relative abundance in the middle reaches of the stream, becoming relatively less important above and below this point. *Choroterpes* sp., whilst present at all sites, was a more important part of the fauna at the upper sites while *Baetis* sp. increased in relative importance upstream.

TABLE IV

The abundance of aquatic macroinvertebrates in terrestrial vegetation trailing in the Rivers Gilgil and Murindati

Caractéristiques des échantillons prélevés dans les portions de végétation traînant dans les rivières Gilgil et Murindati

Site	Number of samples	Total number of invertebrates in all samples	Total dry weight of vegetation, (g) in all samples	Number of individuals g^{-1} dw vegetation
1 (R. Gilgil)	4	89	58	1.53
2 (R. Gilgil)	2	94	82	1.14
3 (R. Gilgil)	3	308	80	3.85
8 (R. Murindati)	2	221	52	4.25

Table IV shows the abundance of all groups of macroinvertebrates in trailing vegetation. It was found that there were between 1.14 and 4.25 individuals g^{-1} DW vegetation, equivalent to between 250 and 1 200 individuals m^{-2}, by calculation from the average weight of vegetation in a 1 m^{-2} quadrat. It was not possible to estimate the abundance of trailing vegetation in the river although it was clear that only a small area of the river contained such vegetation. Studies of the abundance of macroinvertebrates on submerged water plants in the temperate zone report numbers varying from 1 000 to over 40 000 individuals m^{-2} (ROOKE, 1984; MAURER and BRUSVEN, 1983). This suggests that trailing vegetation is a rather poor substrate for macroinvertebrates in the River Gilgil, the maximum numbers of invertebrates on this substrate being similar to the lowest numbers found on submerged water plants in the temperate zone.

5. CONCLUSION

Streams in the catchment of Lake Naivasha appear to support a macroinvertebrate fauna of low species richness. VAN SOMEREN (1952), who also found a fauna of low taxonomic richness in the Sagana River, suggested that this was the result of the recent geological origin of the river and the short time that had been available for colonisation of the river by macroinvertebrates. This suggestion is supported by the observations reported here, as well as by those of HARPER (1984) who found that Lake Naivasha, also geologically recent and isolated from other sources of freshwater, supported an extremely restricted macroinvertebrate fauna. Alternatively it is possible that the impoverished fauna is the result of Navaisha catchment streams containing a relatively small number of micro-habitats in comparison to other tropical streams. Further studies should compare micro-habitat diversity of streams throughout the tropics in order to investigate this possibility.

The observations reported here further demonstrate that tropical streams do not inevitably support macroinvertebrate communities with a greater species richness than those of the temperate zone. However, it appears that MACARTHUR's original hypothesis, that streams in the tropics generally have fewer species of macroinvertebrates (MACARTHUR, 1972), must be modified as a number of studies have reported highly diverse stream communities. Amongst factors which may influence species richness the geological age of a catchment and its streams appears to be important.

ACKNOWLEDGMENTS

This paper formed part of the work of the University of Leicester Research Project at Lake Naivasha in 1982/83. We are grateful to the Office of the President, Government of Kenya, for research permission and to the Director of the National Museums and Chairman of the Department of Zoology, University of Nairobi for formal support. Funding for the project came from the University of Leicester Research Board, Polytechnic of the South Bank, the Royal Society, the Percy Sladen Memorial Trust, the Gilchrist Trust, the British Ecological Society, and others.

We thank the following specialists, all at the British Museum (Natural History) except where indicated, for identifying much of the material used in this study: Mr. S. J. BROOKS (Odonata), Mr. W. R. DOLLING (Hemiptera), Dr. M. T. GILLIES (Sussex University; Ephemeroptera). Mr. P. M.HAMMOND (Coleoptera). Dr. R. W. INGLE (Crustacea), Dr. J. E. MARSHALL (Coleoptera larvae), Mr. C. R. SMITH (Coleoptera) and Mr. K. G. V. SMITH (Diptera). We are grateful to George SHAW, Elwyn BOWLES, Doreen THOMPSON and Marianne CUTLER for assisting with the collecting, to the late Roger MENNELL and Mrs. Lucy MENNELL for accommodation, and to Leicester University Study Tour for allowing us to use their provisions vehicle.

Manuscrit accepté par le Comité de Rédaction le 10 décembre 1987

REFERENCES

BARNARD (P. C.) and CLARK (F.), 1986. — The larval morphology and ecology of a new species of *Ecnomus* from Lake Naivasha, Kenya (Trichoptera : Ecnomidae). *Aquatic Insects*, 8 : 175-183.

BISHOP (J. E.), 1973. — Limnology of a small Malayan river Sungai Gombak. *Monographiae biol.*, 22 : 485 pp.

CRASS (R. S.), 1947. — The may-flies (Ephemeroptera) of Natal and the Eastern Cape. *Ann. Natal Mus.*, 11 : 37-110.

DEMOULIN (G.), 1964. — Mission H. Löffler en Afrique orientale. Ephemeroptera. *Bull. Annls Soc. r. ent. Belg.*, 100 : 279-294.

FERNANDO (C. H.), 1984. — Ecology and biogeography in Sri Lanka. *Monographia biol.*, 57 : 505 pp.

GREEN (J.), 1970. — Streams and meander lakes in the Mato Grosso. *J. anim. Ecol.*, 39 : 4-5.

HARPER (D.), 1984. — Recent changes in the ecology of Lake Naivasha, Kenya. *Verh. int. Verein. Limnol.*, 22 : 1193-1197.

HICKIN (N. E.), 1956. — Larvae of some further East African Trichoptera. *Proc. R. ent. Soc. Lond.* (A), 31 : 66-70.

HYNES (H. B. N.), 1975. — Annual cycles of macro-invertebrates of a river in southern Ghana. *Freshwat. Biol.*, 5 : 71-83.

HYNES (H. B. N.) and WILLIAMS (T. R.), 1962. — The effect of DDT on the fauna of a Central African stream. *Ann. trop. Med. Parasit.*, 56 : 78-91.

ILLIES (J.), 1969. — Biogeography and ecology of neotropical freshwater insects, especially those from running waters. *In* : Fittkau, E. J. *et al.* (eds.), *Biogeography and ecology in South America*. Vol. II. Dr W. Junk, The Hague, 946 pp.

KIMMINS (D. E.), 1955. — Ephemeroptera from Nyasaland, with descriptions of three new species and some interesting nymphal forms. *Ann. Mag. nat. Hist.* (Ser. 12), 8 : 859-880.

LITTERICK (M. R.), GAUDET (J. J.), KALFF (J.) and MELAK (J. M.), 1979. — The limnology of an African lake : Lake Naivasha, Kenya. Unpublished MS prepared for SIL-UNEP meeting on Tropical Limnology, Nairobi, December 1979, 73 pp.

MACARTHUR (R. H.), 1972. — *Geographical Ecology*. Harper and Row, New York, 269 pp.

MAURER (M. A.) and BRUSVEN (M. A.), 1983. — Insect abundance and colonization rate in *Fontinalis neomexicana* (Bryophyta) in an Idaho Batholith stream, U.S.A. *Hydrobiologia*, 98 : 9-15.

NWADIARO (C. S.), 1984. — The longitudinal distribution of macroinvertebrates and fish in a lower Niger delta river (River Sombreiro) in Nigeria. *Hydrobiol. Bull.*, 18 : 133-140.

PATRICK (R.), 1966. — The Catherwood Foundation Peruvian Amazon expedition : limnological and systematic studies. *Monogr. Acad. nat. Sci. Philad.*, 14 : 495 pp.

ROOKE (J. B.), 1984. — The invertebrate fauna of four macrophytes in a lotic system. *Freshwat. Biol.*, 14 : 507-513.

STOUT (J.) and VANDEMEER (J.), 1975. — Comparison of species richness for stream-inhabiting insects in tropical and mid-latitude streams. *Am. Nat.*, 109 : 263-280.

TOWNSEND (C. R.), HILDREW (A. G.) and FRANCIS (J.), 1983. — Community structure in some southern English streams : the influence of physicochemical factors. *Freshwat. Biol.*, 13 : 521-544.

VAN SOMEREN (V. D.), 1952. — *The biology of trout in Kenya Colony*. Government Printer, Nairobi, 114 pp.

WILLIAMS (T. R.) and HYNES (H. B. N.), 1971. — A survey of the fauna of streams on Mount Elgon, East Africa, with special reference to the Simuliidae (Diptera). *Freshwat. Biol.*, 1 : 227-248.

WRIGHT (J. F.), MOSS (D.), ARMITAGE (P. D.) and FURSE (M. T.), 1984. — A preliminary classification of running-water sites in Great Britain based on macro-invertebrate species and the prediction of community type using environmental data. *Freshwat. Biol.*, 14 : 221-256.