Bull. Fish. Res. Stn., Sri Lanka (Ceylon) Vol. 25, Nos. 1 and 2, 1974 pp. 15-26

Limnology and Fishery Biology of the Streams at Horton Plains, Sri Lanka (Ceylon)

by

H. H. COSTA

(WITH 1 PLATE—PLATE I)

The Horton plains (altitude 2,200 m) did not appear in any map of Ceylon until they were marked accurately by General Fraser in 1862. This region consists of rolling plains interspersed with tracts of thick montane forests; characteristic of these plains is the gnarled rhododendron seen growing in isolated patches.

There is only one stream draining the plains which, after receiving water from numerous tributaries, joins the Belihul oya after the Galagama falls.

The Horton plains are subject to both S.W. and N.E. monsoons. Table I gives the rainfall data for the last three years in inches.

	1970	1971	1972
January	3.24	6.99	2.43
February	11.73	3.24	.24
March	6.68	3.52	1.84
April	19.51	14.56	8.32
May	7.51	3.53	11.14
June	4.16	6.00	3.99
July	9.28	6.44	10.33
August	6.65	10.37	5.14
September	4.11	6.50	—
October	8.46	10.00	—
November	9.04	3.29	—
December ..	8.98	14.83	—

Generally the intermonsoon months are dry with frost in the mornings specially in February. The temperatures are generally low; at the time of study (September 1972) the temperature was in the region of 15°C.

The Horton plains stream (Fig. I, the headwaters of Belihul oya) was one of the earliest streams in Ceylon to be stocked with trout (*Salmo gairdneri* Richardson). This stream has been continuously improved by the building of dams and clearing of approaches for stocking these fish.

The stream covers over five miles at an elevation of approximately 2,200 m. At its head (the sources) the tributary streamlets are very small and numerous and these are now covered by peaty mud, knee deep in certain places and the margins fringed with rhododendrons. All around are patanas which are now being utilized for seed potato cultivation. Lower down, the stream has occasional gravelly shallows but in most areas the edges are covered with mud. As the stream descends further and increases in volume many rocky pools are formed and before the

Department of Zoology, University of Ceylon, Vidyalankara Campus, Kelaniya. Sri Lanka

river reaches the Galagama falls it passes over shallow cascades and runs through a miniature gorge. Most of the stretch after Atkinson's bridge shows a very dense and rich growth of *Aponogeton crispum* completely crowding the stream at some places. These and other aquatic plants, fallen rhododendron stems, rocks and other debris are all covered by dense growth of algae. In the cascades and in the rocky areas are also found dense growths of aquatic plants which are overgrown with mosses and algae.

In the upperwaters, the water level is generally low when there is no rain. Generally the bottom is covered with mud except for occasional flat stones which are not exposed. The depth of the water varies considerably in this area from a few centimetres to a metre. The lower waters in certain areas are fairly deep and generally the water is very clear. The current varies along the river, being strong in the cascades and in the waterfalls and changing rapidly with rain.

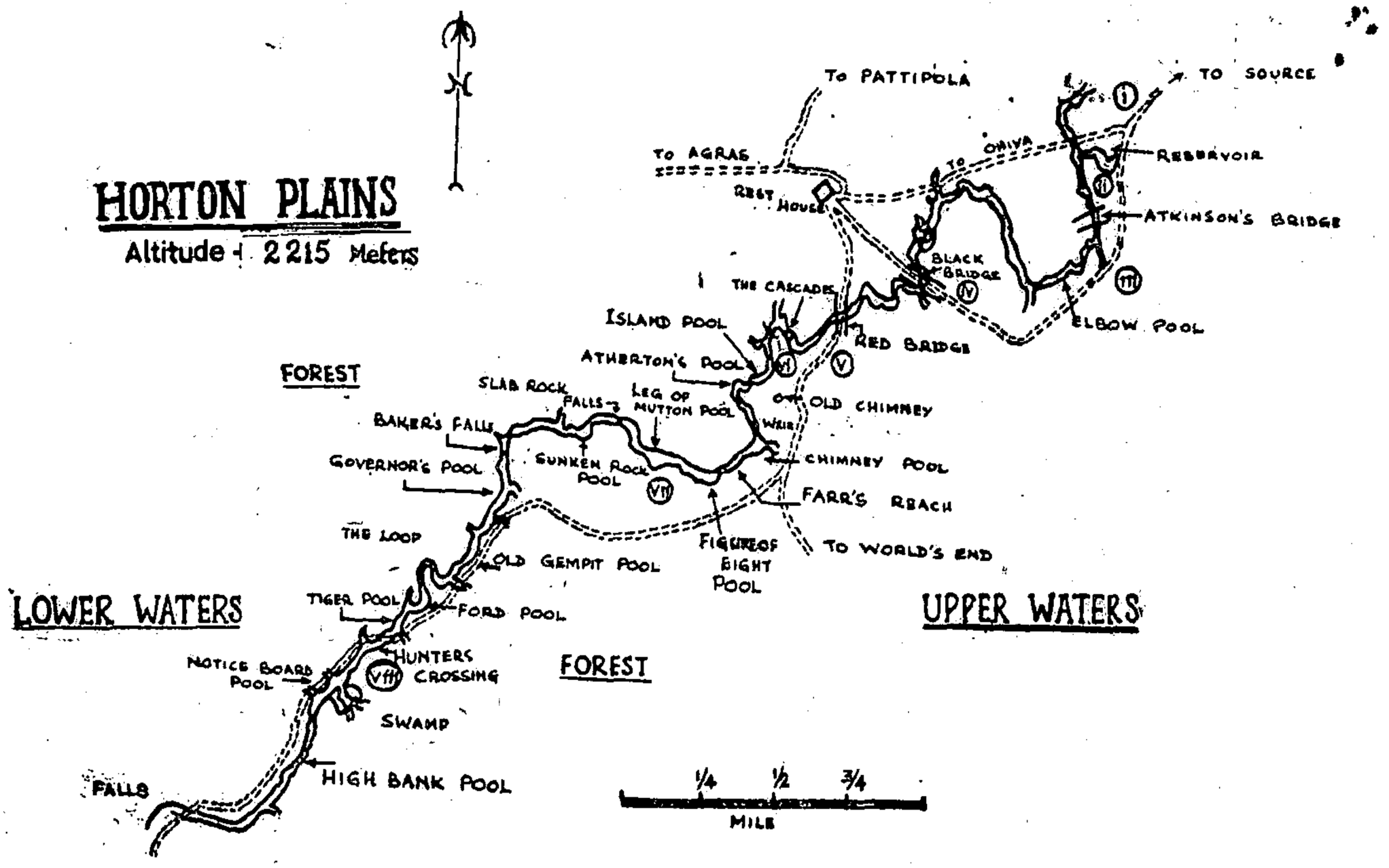


Fig. 1. *Horton plains stream*

Sampling stations

Section I (Plate I Fig. 2 A)

Springs in boggy marshes with occasional large bodies of stagnant water. Muddy bottom with more than a metre deep of mud. Very shallow with very low current velocity (75 cm/sec): no attached vegetation except long trailing grasses on the banks. Stocking of trout is usually done in this area.

Station II (Plate I Fig. 2 B)

The stream is larger with broader patches of water. The width of the stream varies from about 2 metres to about 5 metres in other places. The banks of the stream in this area are muddy, about a metre deep in most places. The depth of the water also varies considerably in this area some times about half metre deep in certain places. In some places the bottom is clear with sand and large stones; these stones being covered with thick layers of detritus and algae; but it was surprising that only a few *Baetis* larvae were seen living on these. However at the time of collection swarms of may-flies, *Baetis* sp. were seen hovering above the water. The banks are covered with trailing grasses with occasional stretches of *Aponogeton*.

Station III (Plate I Fig. 2 C)

Atkinson's bridge—The stream now runs through boggy marshy area with patanas on either side. Much of the stream in this area is overgrown with *Rhododendron* and dense patches of *Aponogeton*. A number of artificial pools alternate with long narrow stretches of water which are very shallow. Again areas of peaty mud alternate with clean sandy patches. No boulders but large and small pebbles are occasionally seen. Water is crystal clear with a dense growth of grass on the edges.

Station IV (Plate I Fig. 2 D)

The Black bridge—The stream is crossed at this station by the road from Ohiya. The narrow stretches of water are generally shallow, depth varying from a few centimetres to about 0.5 metres ; the width of the stream varies from three to four metres. The edges are generally muddy but the bottom at the centre is sandy with small and large sized pebbles. A great deal of algae is found between the stones. Here too as in other places there is a heavy growth of *Aponogeton* on the edges covered thickly with algae. The stones harbour a large number of insect larvae mostly *Simulium*.

Station V

The Red bridge—Large pools about 5-8 metres in width in certain areas alternating with narrow stretches of fast running water. Clear stretches of sandy areas are seen with pebble bottom. Edges of pools densely overgrown with *Aponogeton* which are heavily encrusted with algae; the edges of the pools are still muddy and generally overgrown with long trailing grasses.

Station VI

Cascades—completely rocky bottom; the velocity of the current generally exceeding 100 cm per sec. The rocky surface is exposed in certain areas while at other places they form shallow and sometimes deep pools. *Aponogeton* is completely absent in this stretch but instead this stretch is covered with patches of densely growing other aquatic macrophytes with long narrow leaves; around these patches are large accumulations of soil which abound with large Oligochaetes. Only trailing grasses at the edge but the rock surface, over which the water continously flows, and the rock pools are densely encrusted with algae. Among these and on the rock surface is a very heavy distribution of *Simulium* larvae.

Station VII

Leg of mutton pool ; A long stretch of very large pools situated after the emergence of the stream from its gorge; the patana highlands rise alround with *Rhododendron* thinly dispersed. The velocity of the flow of water coming through the gorge is slowed down by a dam built across the entrance to this pool. The pool itself is situated a few feet below the dam so that the gushing waters flow over a small rock before entering the pool. This pool is specially large with an approximate length of about 20 m. and a width of about 15 m. The banks are fairly shallow silted and covered densely with *Aponogeton*. Numerous small streamlets coming in from different directions from the patanas empty their water into this pool. These narrow streamlets, covered heavily by overgrowths of grass and rhododendron, contain a rich fauna found hiding among the long grasses and decomposing leaf packings of rhododendrons.

The edges of this large pool are completely muddy and the water almost stationary while the bottom of the centre of the pool is sandy where the water flows through with a fairly high velocity. Excessive growth of algae is found on the rocky surface just above the pool.

Station VIII

Before Galagama falls; a slow flowing stretch of water with many pools increasing from small to very big. Most of the pools are deep with crystal clear water with less mud at the edges but with rich growths of trailing grasses on the banks.

METHODS

Several methods are known which have been developed for the study of the fauna in running waters (Macan 1958, Albrecht 1959). Here, as in the trout stream at Horton plains where the stream is small and the substrate heterogenous the fauna tends to be irregularly dispersed. Because of this it is difficult to obtain sufficient samples without disturbing the substrate which would consequently influence the results.

The method of sampling used in this study is based on a method adopted by Thorup, (1970). The method is based on a principle that a series of samples is taken at different sampling stations and the number of samples in which each species occur is noted and converted to percent. In the present study a series of samples were taken from a single sampling station, usually from about fifteen to twenty except at station VIII where the number of samples taken was less. The samples were taken from the edges of the stream, from the algae, from *Aponogeton* and other aquatic plants, from stones of different sizes, from the rock surface, and from the loose soil. Samples were also taken from the stagnant adjoining pools. The samples were collected with a hand sieve. In examining stones, care was taken to see that the surrounding areas were not disturbed. The stones if present at the sampling stations were selected at random, removed immediately the animals dislodged and collected. The species found in each sample were as far as possible identified and the identifications were later verified in the laboratory. The density of animals such as *Simulium* on rock surfaces as in station VI was noted by actually counting the animals in preselected areas.

The frequency values of all species which occured in each station were calculated. As Thorup (1970) indicated these frequency values do not indicate the number of individuals of a species but only their distribution in a certain locality. Thus a frequency value of 100 can occur at high and low individual numbers.

The method used for the analysis of food components was the occurrence method (Hynes 1950).

RESULTS

Chemical characteristics

The chemical characteristics of the head waters of Horton plains during September, 1972, are given in Table II. The analysis was carried out on water samples collected just before the cultivation season of seed potatoes. The waters gushing from the springs were slightly acidic with very little dissolved material. The nitrate, nitrite and chloride values were low at the time of sampling as seen in Table II. But it is possible however, for the nitrate and nitrite values to rise to very much higher levels during the time of seed potato cultivation when fertilizers are used extensively.

Table II.—The chemical characteristics of the head waters of Horton plains—September, 1972.

	Sampling stations							
	1	2	3	4	5	6	7	8
Tem. C° ..	15	15	15	15	15	15	15	15
pH ..	5.3	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Carbonate Hardness mg./l. ..	0.056	0.74	1.540	1.680	1.680	1.400	1.540	1.260
Total Hardness° dH ..	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
CaO mg/l. ..	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
MgO mg/l. ..	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Cl –mg/l. ..	1.42	1.4	1.4	1.4	1.4	1.4	1.4	1.4
NO_2 –mg/l...	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03
NO_3 –mg/l...	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.03
NH_4 –mg/l...	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.04
B.O.D. mg/l.	0.0029	0.0031	0.0023	0.0029	0.0034	0.0034	0.0031	—

Algal characteristics

The stream system shows extensive signs of eutrophication; the banks, stream bottom, rocks, plant remains and even *Aponogeton* all show thick encrustations of densely growing algae. The two commonest algae encountered are *Bulbochaeta* and *Nitella*. *Ulothrix* and *Batrachospermum* were also found; the latter being found mainly in the area of the springs.

Faunal characteristics

Amphibia

Rana limnocharis greeni—Adults and tadpoles. *Rana limnocharis* was the only amphibian encountered in the streams of Horton plains. The habitat of the adult is the bank of the stream among the trailing grasses, *Aponogeton* and the muddy stagnant pools situated alongside the streams. The frequency of occurrence of the frog in the upper part of the stream is very high while in the lower waters it was less frequently found. It was absent in the region of the cascades.

The frequency of occurrence of the tadpoles was very high in the source waters at stations I and II (see Fig. 3) where the pools and the streams were heavily silted. Tadpoles also occurred at stations III and IV and station VII where they were again found in large numbers at the edge of the streams and in the pools.

Frogs showing various stages of metamorphosis were also collected from stations II and III,

It appears that around September is the breeding time for these frogs.

Crustacea

Paratelphusa (Ceylonphusa) enodis

Paratelphusa (Ceylonphusa) rugosa

Caridina singhalensis

There are two species of *Paratelphusa* occurring in the stream. During the sampling period (September) both adult and young *Paratelphusa* showed high frequency values throughout the watercourse except at station I. Frequency values reached almost 100 for the edges of the stream at most of the sampling stations each sample bringing out on an average of 4-5 young ones. The adults which live mostly under stones and at the centre were rare in the catches as they tend to move about rapidly when the stones are disturbed. The largest collected female of *Paratelphusa rugosa* measured 34 mm. while the largest collected male measured 19 mm. On the other hand *P. enodis* is small and the largest male and female collected measured 23 mm. and 20 mm. respectively. The food of the *Paratelphusa* is mostly organic and detritus matter and the presence of these crabs in such large numbers in this stream which is rich in organic detritus is explainable. The only predator of this crab is the introduced trout which feeds heavily on these crabs as shown by the analysis of their gut contents.

Caridina singhalensis is the only other crustacean found in this stream. This shrimp has been earlier recorded only from one other locality in Ceylon, that is from the streams at Moon plains near Nuwara Eliya. Like *Paratelphusa* this shrimp showed very high frequency values throughout the course of the stream except at station I. Beginning with station II, very large numbers were noted in the samples taken from the banks. These consisted mainly of very young shrimps which showed a colour pattern of greenish to light brown. Specimens taken from stations IV, V, VI and VII included adult males and ovigerous females. These shrimps are also detritus and algal feeders and their presence in such predominant numbers must be due, among other things to the availability of food, to the dense growth of aquatic plants at the edges as well as the protection afforded by the trailing grasses which prevent them from being washed down during the torrential conditions that exist after rains.

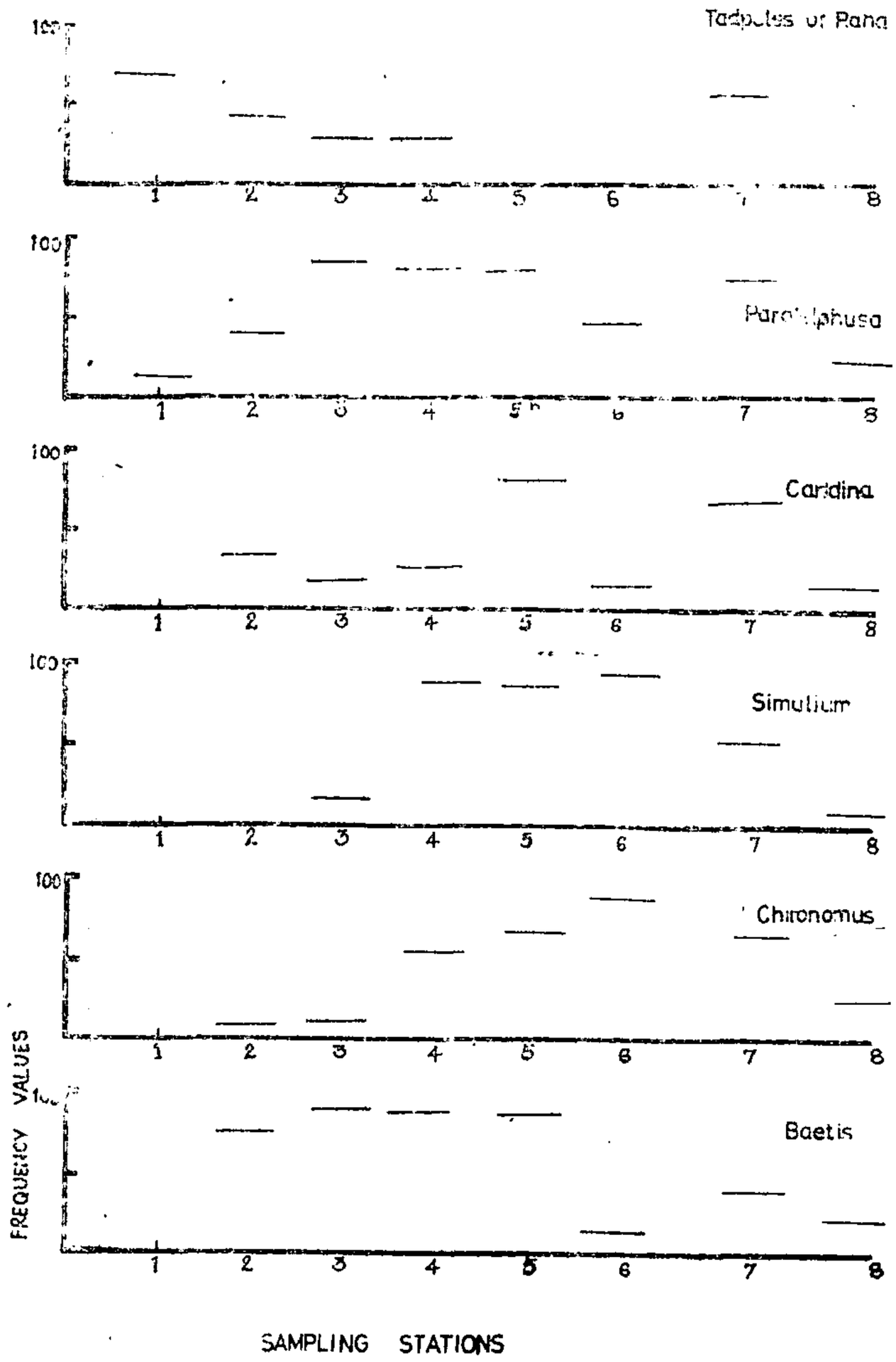


Fig. 3.—Frequency values for the dominating species along the Horton Plains streams

Adult aquatic insects

Hemiptera—*Metrocoris stahli* (Dohrn); This is the only water strider found in this stream. They were found in very large numbers at all the stations sampled except at the cascades. Its habitat is mainly the edges of the stream and the more or less stagnant regions such as the water pools. They usually avoid swimming to the centre of the stream where the current is usually high. They are specially abundant at the regions where the numerous tributaries join the main stream. Insects of all stages of development were very common in the samples taken. The frequency values reached almost 100 at station I, II, IV, V and VII for collections at the edge of the stream.

Anisops ali Dist.—Only one species was encounted and that was also only at station VII. They were not encountered in any other station where intensive sampling had been conducted. Station VII is muddy at the edges with small streamlets pouring their water into a very large pool. Even at this station the frequency values of occurrence were less than 10.

Micronecta sp.—These like the above species were collected only at one station—station V from an artificial pool draining its water into the main stream. In this pool the water was mostly stagnant and the bottom heavily silted with the edges thickly overgrown with long grasses. In this pool they were abundant and the frequency values of occurrence in the samples were very high.

Coleoptera—*Hydrocoptus sp.*—This was collected only at station 1 and was rather rare.

Insect larval forms

Ephemeroptera—

Baetis sp. and *Caenis sp.* were two common ephemeropteran larval forms encountered. However, *Caenis sp.* rarely appeared in the samples. During the time of sampling adult *Baetis* was seen to swarm in large numbers over the water at stations II and III. Nymphs of *Baetis* were in many stations the dominant forms, present in all the niches under stones, among algae and under the trailing grasses, etc. In most stations the frequency values were high. In drift samples taken at station VI (cascades) they appeared regularly in the net and this shows that they form one of the most important food sources of the trout (*Salmo gairdneri*) and this was specially true of the smaller trout. They also constitute the food of other aquatic larvae specially the odonata. Observations on the gut contents of *Baetis* showed that they subsist mainly on diatoms, etc.

Diptera

Simulium sp. and *Chironomus* sp. were the two commonest dipteran larval forms. *Dixa* sp. also appeared in samples of detritus taken at the edge. High frequency values of occurrence for *Simulium* were noted for most part of the stream and frequency values were high specially for the lower part of the stream. They were completely absent at station I. Low frequency values were noted for stations II and III. Such low values for stations II and III may be because of the unsuitable substratum for this species in this part of the brook. In other parts of the stream this species was not only found attached to submerged rocks and rocky surfaces but also found in heavy numbers on submerged logs, on dead leaves and even on aquatic plants. Their distribution reached maximum at the cascade regions (station VI) where they reached astounding numbers (more than 5000 per 1/16 sq. metre). This condition was generally seen over most of the submerged rock surface and near the water fall just before station VII. Drift samples taken at station VI showed large numbers of *Simulium* in the drift net. They are also a very common food item of the smaller trout.

One species of *Chironomus* occur throughout the stream reaching highest frequencies between stations III and VIII. At station I the frequency of occurrence is less. The high frequency of occurrence for this species may be because favourable habitats are present namely algal and moss growths on stones, rocky bottom, piles of dead leaves and large quantities of detritus. This species is very small and at stations V and VI where algae, detritus and other material collected from a 1/16 sq. metre area showed the presence of more than 100 individuals per measured area.

Dixa sp. is a food source of the trout and was observed in most of the trout examined for their food.

Rhyacophila sp.—This is a large carnivorous species with prominent frequency values at station II, V and specially at VI (cascades) and just at the water fall before station VII. At station VI the substrataum (rocky bottom) is an ideal habitat for these larvae where large numbers were noted in the samples. In other areas usually only single specimens were taken in the samples and that too was rare and as such frequency values recorded were low.

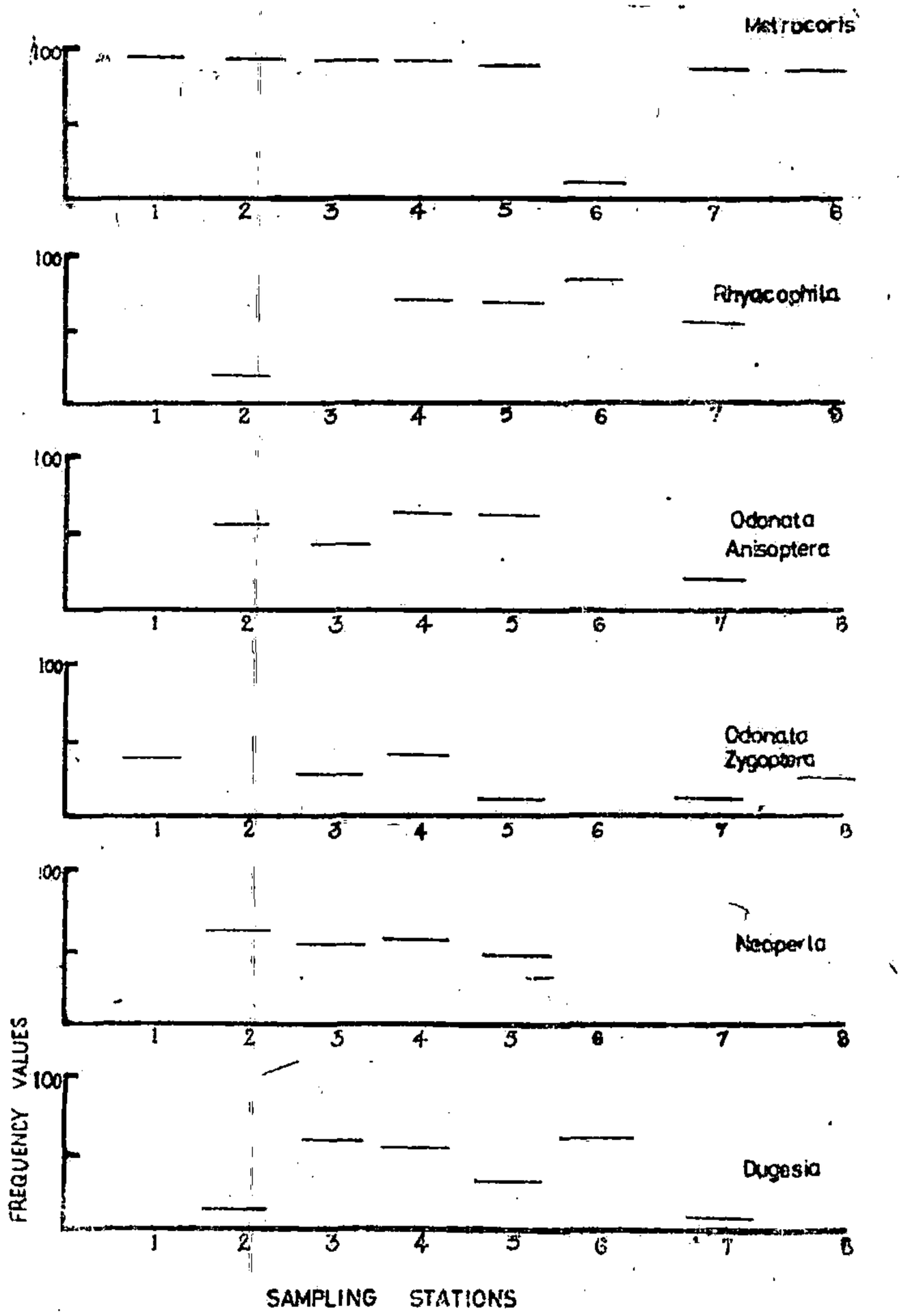


Fig.—4 Frequency values for the dominating species along the Horton plains stream.

Odonata

Zygoptera—Nymphs of three distinct zygopteran species were taken in the samples. One belong to Libellulidae, one to Gomphidae and the other to Aeshnidae. The Aeshnid larva was long and elongated . The Libellulid nymphs never attained recognizable frequency values. They were found along the banks at station I, station IV and station VIII. The gomphid species is more widely distributed than the previous species although absent at station I and VI. Their occurrence is also along the banks and in areas with floating vegetation. The aeshnid species was recorded only from station III and VIII. Their habitat is similar to the other species.

Anisoptera—Only one species belonging to Coenagrionidae, showed high values, throughout the water course. Normal habitats are the banks among the algae and the water plants.

Plecoptera

Neoperla sp.—Only one species was found. Nymphs were found in the regions of the stream where the conditions of the substratum was most suitable; they were not collected in samples from station I. High frequency values were obtained at stations II, III, IV and V; their habitat

being the stones and boulders in the middle part of the stream where the current velocity is higher. The food of these nymphs consists of detritus and algae which are brushed off from the stones. Samples taken from the banks occasionally showed their presence.

Dugesia nannophallus—Except at station I this planarian was widely distributed. Its habitat is loose stones, rock surfaces at the centre of the stream, amongst algae and decomposing matter. They were numerous in the region of the cascades.

Limnodrilus hoffmeisteri—This freshwater oligochaete was present in the mud samples from the muddy banks at stations I, II, IV and VII. Although the frequency of occurrence in the samples was not very high, it appears probable that this species is more widely distributed.

Paludomus nigricans—This was the only mollusc found in these streams.

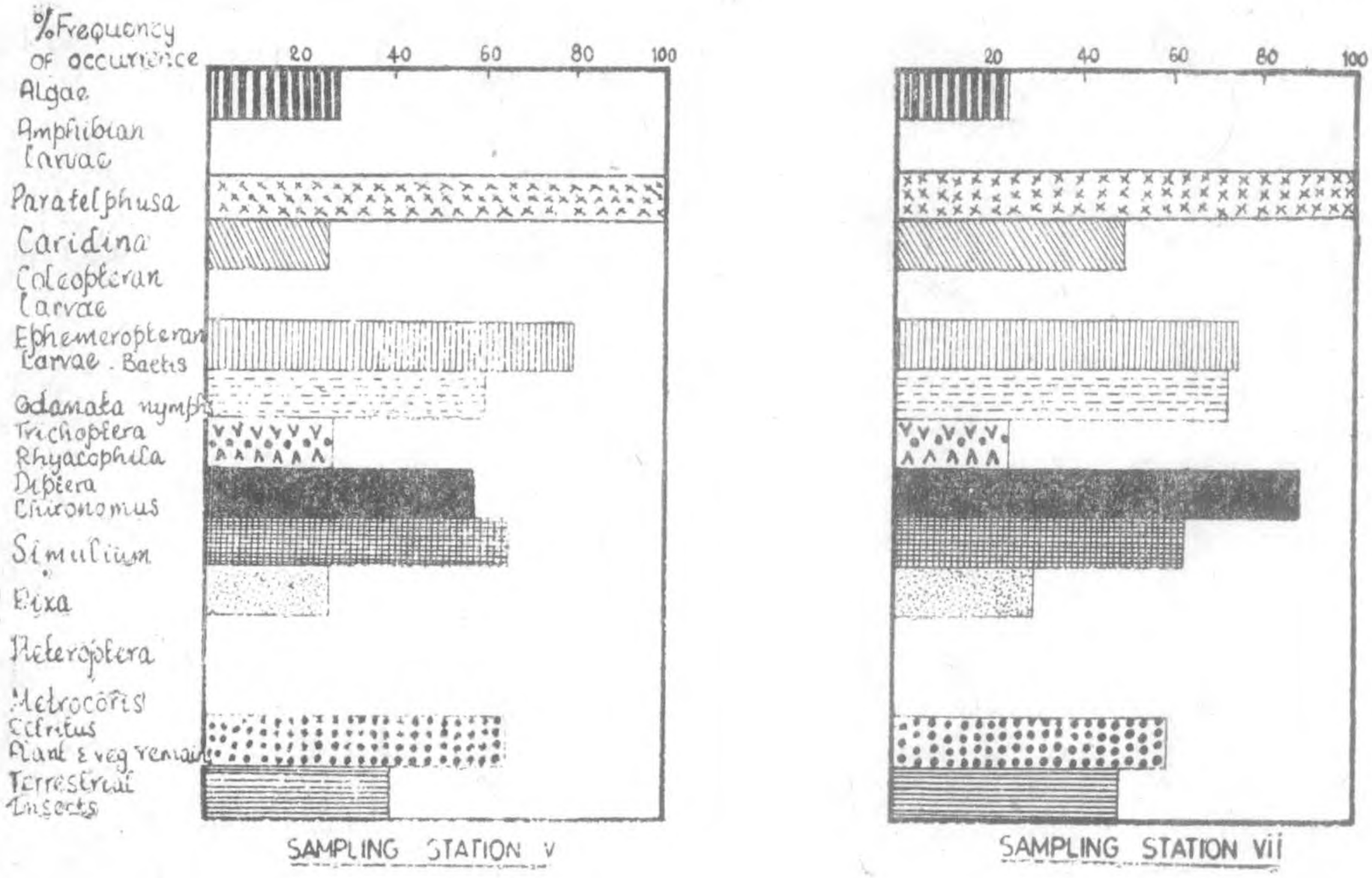
Salmo gairdnerii—There are no indigenous fish in the stream at Horton plains. The only fish found is the introduced rainbow trout *Salmo garidnerii* Richardson. This species was first introduced to Ceylon in 1839 and later stocked at Horton plains stream. According to the data maintained by the Ceylon Fishing club's hatchery the average size of fish caught consists of 3/4 lbs. to 1½ lbs. weight, and an occasional fish weighing up to 5-6 lbs. Because of the recent potato cultivation at Horton plains the upper water regions have become heavily silted with the result that the fish are now mostly confined to the lower waters. In these waters the fish are found anywhere usually resting and feeding at the bottom.

During the time of study (September 1972) a number of trout of varying sizes were caught from two stations. These fish were measured and their gut contents were studied to determine the food items. They varied from 8½ inches to 10½ inches. Six trout were caught from station V and seven were caught from station VII. Fig. 5 gives the percentage occurrence and the percentage composition of the food taken by the trout during September in the Horton plains streams. These results indicate that the food taken by the trout living in the stream show a direct relationship to the abundance of the available food material in the stream. All the trout collected and examined for gut contents showed that a substantial portion of the diet consisted mainly of young *Paratelphusa*. The insect larvae most preferred are the *simulium* larvae, chironomid larvae, dixid larvae, odonata larvae and *Baetis* larvae. Most of these larvae seemed to be taken whole; specially the chironomid larvae is taken in lumps with the detritus. Young crabs are also taken whole. There are also considerable amounts of vegetable and leaf matter, detritus and algae in the diet; which presumably are taken indirectly with the other food items. Adult terrestial insects also formed a common component of the food.

DISCUSSION

One of the most disturbing factors in the recent years has been the indiscriminate exploitation of the Horton plains for the cultivation of seed potatoes. As a result of this, two obvious features have been introduced to the stream. Firstly, the tilling of the land around the streams has now resulted in the most parts of the stream becoming silted. Secondly, the use of the fertilizers has resulted in extensive entrophication of the stream, which is about the first clear example of a hill country stream subjected to this process. However, the source waters are continuously being replenished by the innumerable springs so that eutrophication has not led to the deoxygenation of the water.

Three observations of some interest were also noted in this study; most important of which was that these streams do not have indigenous fish; second was that the stream fauna was dominated by detritus feeding animals. The third was the very extensive growth of algae (mostly *Bulbochaeta*) on the banks, water plants, stones etc.



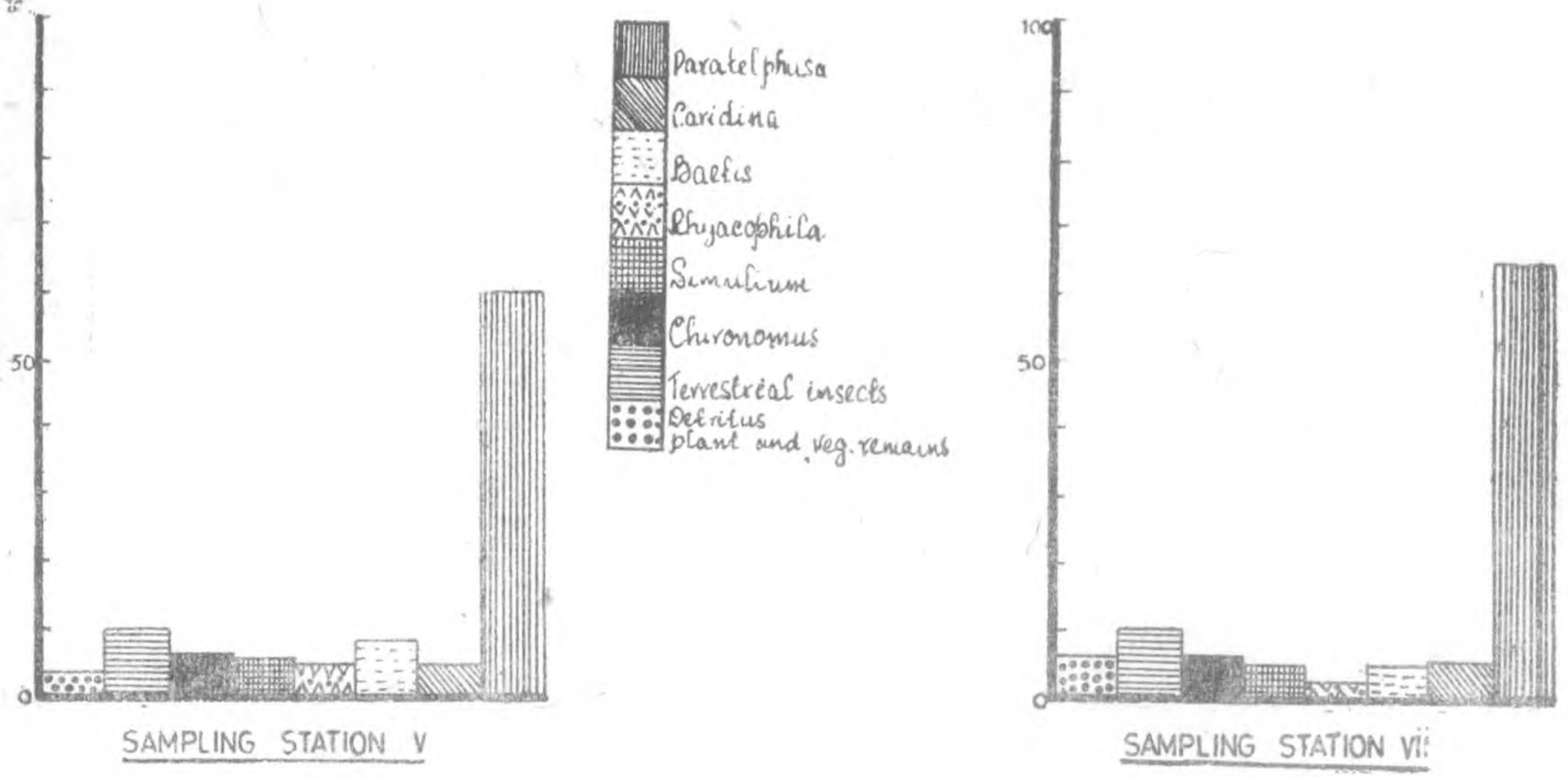


Fig.—5 The percentage occurrence and the percentage composition of food taken by trout in the Horton Plains streams during September 1972

The frequency values to some extent indicate the varying ecological conditions that is manifested in the different parts of the stream. The high frequency values for crabs, shrimps, *Simulium* sp. and *Chironomus* sp. may be the direct result of increase of organic particulate matter in the stream; the increase in the organic particulate matter and of the above species and *Limnodilus* in the stream is also indicative of some degree of pollution.

At the time of sampling the land was being prepared for the cultivation of seed potatoes and as such the analysis of the stream waters did not reveal any nitrates or nitrites in recognisable quantities but the fact that fertilizers have been extensively washed into the streams is indicated by the overgrowth of dense algae.

Table III gives some data, (maintained by the Ceylon Fishing Club) about the trout stocked and taken from the Horton plains streams.

Table III

Period in Years	*Stocked*	*Taken*
1949—1959	8716	2083
1961—1971	7476	903

These data indicate that the trout taken from the streams have considerably decreased in the last decade although the fishing effort (maintained by the club) during the two decades has not been much different. It was in 1961 that the surrounding environment was disturbed for the cultivation of seed potatoes. With the use of fertilizers and possibly pesticides it is possible that these, to some extent, would have had some deleterious effects on trout. It is true that the fresh water gushing from the innumerable springs situated above the cultivation areas could wash off the fertilizers and other pollutants rapidly downstream. Yet trout fry being very sensitive to conditions in the environment, the possibility of some of the trout fry being affected in some way or other exists.

The results also indicate that the substratum seems to be the regulating factor for the distribution of most of the species in the stream except for *Paratelphusa* sp. which is the dominating and most widely ditributed species in the locality. The distribution of the fauna may be also correlated to the feeding biology of the different species. Some animals are associated with submerged stones, detritus, piles of dead leaves, rocky bottom and algae which are differently distributed in the stream.

The catching organs of animals such as *Simulium* larvae are well suited for collecting very finely divided detritus. Pollution increases the amount of such microscopic detritus in water courses and Nielsen (1950) has indicated that pollution leads to a considerable increase of *Simulium* larvae.

The results of the gut analysis indicate that crabs form the main food component of the trout. With the abundantly present crabs in the stream, it should be possible to stock the stream with more trout if proper measures are taken to prevent deleterious substances entering the water.

It is interesting to compare the results obtained for the waters and fauna of Belihul Oya (Costa and Starmühlner, 1972), which is the continuation of the Horton plains stream, with those of the present study. Although the ammonia content and hardness are more or less the same, the downstream waters at Belihul oya, were of a higher pH. and contained more nitrates, calcium and magnesium. The fauna at Belihul oya is very much different to those of the waters of Horton plains. At Belihul oya a greater variety of fauna were seen and this was specially the case with fish. *Garra, Nocmacheilus and Puntius* species which were completely absent in the Horton plains streams were abundant at Belihul oya. The temperatures of the waters at Belihul oya are very much higher (21°C) than those of the waters of Horton plains streams (15° C.); perhaps this may be a reason why no trout were seen at Belihul oya although Belihul oya is situated only a few miles from Galagama falls.

SUMMARY

1. The present study deals with the chemical, algal and faunal characteristics of the stream system at Horton plains—the highest plains in Ceylon (altitude 2225 m).

2. The cultivation of seed potatoes and subsequent use of fertilizers have caused extensive silting and severe entrophication of the stream systems.

3. There are no indigenous fish. Introduced trout *Salmo gairdnerii* is the only fish found in these streams.

4. The commonest fauna in the streams are crabs (*Paratelphusa* sp.), shrimps (*Caridina* sp.), *Simulium* sp. and *Chironomus* sp. Their increase in number is probably correlated with increase in organic and detritus matter.

5. The most important food item of the trout are the crabs living abundantly in the stream, insect larvae and terrestial insects were also commonly found in the guts.

6. Records of stocking and taking of trout in the Horton plains streams have shown that now less trout are taken relatively to the numbers stocked. This decrease may be possibly due to the eutrophication of the stream and also due to the possible use of pollutants in connection with the cultivation of seed potatoes.

ACKNOWLEDGEMENTS

I am very thankful to Mr. Harold Peiris for hosting us at Farr Inn Hotel during our stay at Horton Plains and to Mr. W. D. Gunatilake for helping me with the chemical analysis.

REFERENCES

Albrecht, M. L. (1959) Die quantitative Untersuchung der Bodenfauna fliebender Gewasser—Z. Fich 8 NF: 481–550.

Costa, H. H. and Starmühlrer F. (1972) Results of the Austrian—Ceylonese Hydrobiological mission 1970 of the 1st Zoological Institute of the University of Vienna, (Austria) and the Department of Zoology, Vidyalankara University of Ceylon, Kelaniya, Part I preliminary report : Introdultion and description of the streams-Bulletin Fisheries Research Station of Ceylon.—23. *pp* 43-76.

Hynes, H. B. N. (1950)—The food of the freshwater sticklebacks *Gasterosteus aculeatus* and *pygosteus pungitius* with a review of methods used in the studies of food of fishes, J. Anm. Ecol. 19, 35–38.

Nielsen, A. (1950)—The torrental Invertebrate fauna. Oikos 2, 176–196.

Thorup, J. (1970)—Frequency analysis in running waters and its application on a springbrook communty. Arch. Hydrobiol. 68. 126–142.

Macan, T. T. (1958)—Methods of sampling the botton fauna in stony streams. Mitt. Internat. Verein. Limnol 8, 1–21.