ONCHOCERCIASIS CONTROL PROGRAMME
IN THE VOLTA RIVER BASIN AREA

SCIENTIFIC AND TECHNICAL ADVISORY COMMITTEE

Fourth meeting
Geneva, 2-4 November 1976

Agenda item 4(c)

ENTOMOLOGICAL RESEARCH 1976

At the third meeting of the Scientific and Technical Advisory Committee, a document was presented detailing the programme of research for 1976. Reports from the different institutes and scientists engaged in this research have been circulated, as they became available, to STAC members and the purpose of this review is to summarize the progress made to date in the fields of vector ecology and environmental protection. Research in connexion with insecticides is contained in a separate paper.

Vector Ecology

The development of a self-perpetuating colony of S. damnosum s.l.

Progress in this field has been slow and hampered by the difficulties encountered in transporting fresh material, eggs in particular, from West Africa to the two laboratories engaged in this activity, namely, the Center for Disease Control, Atlanta (Dr R. Taylor) and the Tropenmedizinisches Institut, Tübingen (Dr J. Grunewald). Invariably, the time involved in transit was too long resulting in the material being in an unusable state on arrival.

Two methods of transportation have been tried in particular. The first is placing eggs on ice in a Thermos flask which is then sent air-freight. (This method has worked only when the flask was carried by hand from West Africa to the laboratory without delay.) The second is airmailing eggs sealed in a plastic bag in an envelope. This seems to be more promising when they are sent to Europe, if there are no delays en route.

No information has been received from Dr Taylor who has, meanwhile, been continuing his studies with S. decorum and S. vitattum in the absence of regular supplies of S. damnosum.
Dr Grunewald has recently signalled some success with two batches of eggs he received and which he was able to rear to the adult stage. Some of the adults and larvae were fixed for taxonomic identification. Two of the reared S. damnosum females were induced to blood-feed and stimulated to oviposit. The two good batches had 422 and 176 eggs but, unfortunately, they were not fertilized. He has constructed an apparatus with a stirring and heating system for artificial blood-feeding of blackfly females. In 67 feeding experiments with a total of 865 blackfly females, 52% took a blood meal.

In his system, experience has shown that the Monstera plant which he has used to eliminate the different ions (mainly toxic nitrogen compounds) is overly sensitive and stops assimilating as soon as there are light and temperature changes. Dr Grunewald is now currently testing new special ion exchange resins for purifying the water of his rearing system. He feels that such an ion exchanger would give more constant results and would facilitate a smaller rearing system and therefore be much easier to handle.

At the beginning of 1977, Dr Grunewald was recruited as WHO consultant to test the water quality (a) at breeding sites where different cytotypes of the S. damnosum complex are found, and (b) at places potentially suitable for establishing a rearing laboratory. He noted in particular the hydrophysical factors (water temperature, pH values and conductivity), the dissolved gases (particularly oxygen content and free carbondioxide), the main cations (calcium, magnesium, sodium and potassium), the main anions (carbonate, chloride, sulphate), the nitrogen compounds (ammonium, nitrite, nitrate), phosphate, silicate, and concentration of organic matter.

Dr Grunewald found that based on these factors the cytotypes studied could be divided into two groups according to ecological requirements. Group 1 included Bandama (S. sanctipauli) and Yah (S. yahense) which were found in sites with, amongst other things, pH values ranging from 5.7 to 6.2 and the conductivity always below 50 μmhos. Group 2 included Sirba (S. sirbanum), Nile (S. damnosum), Bille (S. squamosum) and Soubre (S. soubrense) in water which was neutral, weakly acid or weakly alkaline and conductivity varying from 50 to 150 μmhos. From his studies, Dr Grunewald was able to indicate possible locations for a rearing laboratory.

Dr Raybould was recruited as a research entomologist on the Programme to establish a laboratory in close proximity to the Programme area for rearing adults of the S. damnosum complex. He has been temporarily assigned to Bouaké to assist with the research associated with the reinvasion problem and has been engaged in obtaining eggs from
wild-caught blood-fed females and rearing larvae and adults for
taxonomic identification of the incriminating species. Using
relatively conventional methods, he has had a very high level of
success and contributed greatly to this research programme, which will
be reported in detail elsewhere.

It is anticipated that Dr Raybould will shortly have a laboratory
established in Ghana and, as well as being in a position to produce
related eggs, larvae, pupae and adults of the different cytotypes of
the S. damnosum complex for those engaged in studying their taxonomy,
he will be able to investigate some of the major obstacles to developing
a laboratory colony, such as mating, ovipositing and feeding.

S. damnosum complex

Substantial progress of practical importance has been made during
the course of the year in determining morphological characteristics which
can be used in identifying the adults of the different cytotypes of the
S. damnosum complex. Dr Quillévéré, under the agreement established
with the Organisation de Coordination et de Coopération pour la Lutte
contre les grandes Endémies, Institut de Recherches sur l'Onchocercose,
Bouaké, has made a detailed study of the adults obtained from
individual breeding sites where one or other of the cytotypes is almost
exclusively found. In this way, he has been able to use a combination
of the antennal form and the number of teeth on the maxillae to
identify adults in the Nile/Sirba, Bandama/Soubre and Bille/Yah cyto-
type groups. The applicability and usefulness of his method has been
borne out in practice during the recent study of the reinvasion problem
where the flies involved were shown to belong to the Nile/Sirba group.

Dr Quillévéré has found from a longitudinal study of a series of
breeding sites on the Marahoué at Danangoro, where is situated the
field station of the Institut de Recherches sur l'Onchocercose, that
there is a considerable shift in the composition of cytotypes pre-
dominating at different times of the year. In November, the beginning
of the dry season, Soubre represents 8% and Nile/Sirba 20%, whereas
in April, at the end of the dry season, the population is composed
of 80% Nile, 15% Sirba and 5% Soubre.

Dr Grunewald reports a similar change in the Cavally river at Lieupleu,
Ivory Coast. During his study in February and March 1976, reported
above, he recorded only Bille (S. squamosum), whereas at other times
of the year, it seems that Yah (S. yahense) is found there. This
reflects a seasonal change in the water quality from a normal to
alkaline situation to an acid one.

Dr Vajime, research cytotaxonomist, working full-time for the
Programme, has continued to identify and plot the wider distribution
of the different members of the S. damnosum complex in the Phase III
zones and in rivers to the south of the Programme area. He has also tried to find polytene chromosomes in the adults which could be used for identification purposes, but so far without success.

Dr Bedo, an Australian research worker, supported by a small grant from WHO, examined the pupae and adults of eight blackfly species in Australia and found that the so-called C and G banding technique may produce specific features. He also found that some had chromosomes in the Malpighian tubules suitable for detailed cytological analysis. The opportunity is being afforded to Dr Bedo to try out his techniques on S. damnosum s.l. later in the year in association with Dr Vajime and Dr Quilléverô. Meanwhile, Dr Vajime, using the C banding technique, has observed the C banding of centromere regions in larval polytene chromosomes of the S. damnosum species group. The expression of the region was most conspicuous in S. squamosum and S. yahense. He found that there were no reverse banding sequences with respect to standard to provide landmarks for species identification.

As the year progressed and as a result of the efforts of Dr Raybould, material started to be sent to Dr Peterson in the Biosystematic Research Unit in Ottawa, with whom an agreement was established for an in-depth taxonomic study of the different stages of the various West African members of the S. damnosum complex. A total of 55 morphological characters in adult females have been studied in the first instance. Frequency distribution of 33 characters were plotted resulting in three main patterns. The species S. sirbanum and S. soubrense can be separated from one another by a combination of the following characters:

- length of mid basitarsus
- length of fore basitarsus
- length of fore femur
- length of wing
- length of palpal segment
- number of spines on wing vein R

There was no evidence that colour class, rearing habitat or collection site affected the grouping.

Dr H. Townson, Liverpool School of Tropical Medicine, has undertaken studies on enzyme polychromosomes in members of the S. damnosum complex/an agreement with OCP. He has a research assistant based in Akosombo in Ghana. Ten enzymes have so far been examined in blackflies and, of these, esterase, \(-\)glycerophosphate dehydrogenase (\(-\)GPD) and Alcohol dehydrogenase (ADH) have been selected for examination in larger samples with a possible subsequent addition of Glucose-6-phosphate dehydrogenase (G6PD) and Xanthine dehydrogenase (XDH). There is some evidence that ADH bands differ in S. sanctipauli, S. squamosum, S. damnosum + S. sirbanum. This tentative conclusion is complicated, however, by inconsistencies in band positions which may
reflect experimental error or real variations in mobility in individuals in a single site. Improved methods of preserving material are being sought as delays in its trans-shipment from Africa to Liverpool have resulted in much of the material being unusable on arrival.

Considerable debate continues as to whether the different members of the S. damnosum complex should be considered as cytotypes or species or even cytospecies. It is hoped that this problem can be resolved and a more coordinated and co-related programme of research developed at a meeting to be convened in Geneva from 15-19 November 1976 to consider vector species complexes when all those engaged in this research for OCP and workers involved with other vectors will assemble together.

S. damnosum sampling

The principal studies in this field continue to be carried out at the Institut de Recherches sur l'Onchocercose, Bouaké, under an agreement with the Office de la Recherche scientifique et technique Outre-Mer. As reported above, the field station, Danangoro, where these studies are mainly carried out, is affected by a change in distribution of the cytotypes of the S. damnosum complex. Accordingly, close attention has to be paid to what cytotypes are being sampled to assess whether any sampling system developed has a potential application in the Programme area where Sirba and Nile predominate. Because of the limited range of cytotypes at Danangoro, it may not be the most appropriate place to carry out this particular type of research but as the control operations become more effective and widespread, the more difficult it will be to locate a suitable alternative research station in reasonably close proximity to the OCP area.

Dr Bellec has continued to pursue his studies towards the development of a trapping device for adult Simuliidae. He has tried his windowpane trap, which consists of either a sheet of glass or clear plastic coated with a sticky substance and suspended over a river just above the surface and in close proximity to a breeding site. Using this interception trap, Dr Bellec has caught relatively large numbers of Simulium adults in flight, males as well as females. Newly emerged, gravid and non-gravid females were taken, so representing a different type of sample than that normally attracted to human bait.

By erecting a series of these traps at several locations along the different arms of the water course, Dr Bellec noted variations in behaviour. Gravid females and older males of S. damnosum and S. adersi were caught on the traps furthest upstream, whereas newly-emerged adults tended to be caught further down. From the numbers and categories of flies caught on either side of the screens, there seemed to be a pronounced movement of males and gravid females in an upstream direction,
but in reverse, i.e. downstream, of newly-emerged adults; for older non-gravid females, there is no pronounced tendency. With traps placed one above the other, Dr Bellec was able to indicate that the adult flies tended to move along the rivers just above the surface.

The second type of trap tried out was an aluminium sheet 1 metre sq., again coated with a sticky substance and laid flat on the ground. Results with this trap were variable and seemed to depend, amongst other things, on its position relative to the river and nearby breeding sites. As with the windowpane trap, the physiological stages of adults caught were very varied and different from those attracted to man for a meal.

To catch different categories in this way can certainly be advantageous in leading to a fuller understanding of the biology and flight behaviour of the blackfly but, in view of the variation in cytotype or species composition in the experimental area, it is obviously necessary, (a) to identify those blackflies caught for the results to be meaningful and comparable, and (b) to have any trapping device developed and tried out in an area where the Sirba (S. sirbanum) group predominates as this will then determine its possible applicability to the Onchocerciasis Control Programme. However, as the Programme's prime objective is to interrupt transmission of the disease, the population sample taken by any trap must be such as to give as clear an indication of the potential transmission index as those flies currently caught by vector collectors.

A complete review of adult trapping methods and a determination of future research in this field were included in the agenda of the SAP Working Group held in Geneva from 26-29 October 1976, the report of which is presented separately to STAC.

Mr Elsen, operating under the same agreement and also supported by the Leopold Institute, Antwerp, has continued his study of larval sampling devices. As already reported, he has found narrow plastic strips to offer useful support; with these he was able to record larvae and pupae at depths of 3 metres greater than ever noted before. However, insofar as control has been established successfully in the OCP area, this ability of the larvae does not seem to put them out of the reach of the insecticide formulation used. The acquisition of a micro-current meter with direct reading has enabled Mr Elsen to demonstrate striking parallels between the speed of current and the distribution of pre-imaginal stages. He has observed the larvae in different situations and under varying conditions resulting in further information being collected on some aspects of larval behaviour.

Mr Elsen has also studied the rate of transition of food particles through the gut. It seems that the transit speed is similar in the middle third of the digestive tract and that the complete transit
time for the same larvae can vary from 1-3 min. and is shorter in
the early instars. This information could be useful for the develop-
ment of certain insecticide formulations.

Mr Elsen has found that pupation and hatching cycles follow
similar patterns, i.e. one peak early in the morning and another late
in the afternoon, their respective size depending on climatic con-
ditions.

It is obvious that these studies on development of sampling
methods are providing a greater understanding of the bionomics of the
blackflies but it will be essential in future, for the work to be
of value to OCP, for more attention to be paid, as already stated, to
the actual cytotype or species of the Simulium damnosum

Simulium dispersal

This aspect of research is being reviewed separately in relation
to the reinvasion problem and is included in the deliberations of the
SAP Working Group mentioned above.

Environmental protection

The aquatic monitoring programme continues to be carried out under
agreements established with the ORSTOM Hydrombiological Unit in Bouaké
and the Institute of Aquatic Biology in Achimota, with additional
ichthyological studies by Dr Roman, Ouagadougou.

The protocol finalized in June 1975 has been followed carefully
at selected sampling sites on a range of rivers and, by means of coded
forms, all data is forwarded to Geneva for computer storage and
subsequent analysis.

Two meetings of the group involved have been held during 1976, the
first in January (Bouaké) and the second in July (Accra), at which
some of the problems encountered were discussed and resolved and
activities generally coordinated. It is planned to hold the next
meeting in January 1977 in Ouagadougou and this will be a working group
to consider the identification of some of the aquatic invertebrates
found.

The ORSTOM group in Bouaké made a comparison of two different
types of artificial substrates following which the most suitable,
consisting of concrete blocks of similar size suspended from a metal
bar, has been adopted throughout the area. The lack of baseline
data on many of the rivers prior to control makes it difficult to draw
sound conclusions on the impact of the first complete year of control,
but the ORSTOM group infer in their annual report that there is a certain reduction of the invertebrate population in the treated rivers and that this does not seem to be having an adverse affect on fish development. Great emphasis is being placed on the data currently being collected from the Bagoé and Oti rivers in the Phase III area prior to the commencement of control in 1977.

Dr Roman has catalogued all the fish found in samples taken from a few sites in rivers of Upper Volta, which will form useful baseline material for comparison in later years. He reports that so far the Abate treatment does not seem to be affecting the breeding females nor the development of the young of the fish species present.

Dr Pugh Thomas, University of Salford, United Kingdom, prepared an independent report for the Ecological Panel of the situation up to the end of July, as gleaned from the data already sent for computer storage, and this is attached.
BIOLOGICAL MONITORING
IN THE
ONCHOCERCIASIS CONTROL PROGRAMME

A report for the period
January to August 1976.

Prepared by
M. Pugh Thomas, B.Sc., Ph.D

1 August 1976
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SUPPORTING DOCUMENTS (not included in this report)

Rapport des Missions sur la Faune Ichthyologique, Crustaces Decapodes et Lamellibranches dans le Cadre du Programme de Lutte Contre l'Onchocercose by Dr B. Roman, June 1976.

R.S.T.O.M. Rapport No. 2, 1976 by G. Vidy
Etude du régime alimentaire de quelques poissons insectivores dans les rivières de Côte d'Ivoire.

R.S.T.O.M. Rapport No. 3, 1976 by C. Dejoux and P. Venard
Efficacité comparée de deux types de substrats artificiels


Copies of the final versions of the Recording Forms.
1. INTRODUCTION

This report to the Ecological Panel of the Onchocerciasis Control Programme follows on from the report prepared in February, 1976. Like the earlier report it is concerned solely with the biological monitoring and does not discuss chemical techniques and data.

2. MEETING OF MONITORING GROUPS

A meeting of the three monitoring teams was held in Accra, Ghana, from the 7th-9th July 1976. The meeting was held at the Institute of Aquatic Biology (I.A.B.) and was chaired by Dr Martin Odei. In addition to representatives from the O.R.S.T.O.M. team at Bouaké, the Institute Team at Tamale and Mrs Brenda Walsh and Dr Roman from Ouagadougou, Mr J. Duppenthaler from WHO, Geneva, Mr Frank Walsh from WHO, Ouagadougou and Dr M. Pugh Thomas from The University of Salford, Britain, were present.

In addition to attending the meeting in Accra, Dr Pugh Thomas also visited the monitoring team in Tamale and worked with them in the field at Daboya on the Black Volta and at Sabari on the River Oti.

An account of the meeting was prepared by Dr Pugh Thomas and is presented to the Panel as a separate document.

The Ghanaian team at Tamale appear to be working well, but some minor problems were noted.

3. THE PROTOCOL FOR AQUATIC MONITORING

The O.R.S.T.O.M. team at Bouaké and the Institute of Aquatic Biology team based at Tamale in Ghana are now both using all the techniques described in the revised protocol for aquatic monitoring whenever river conditions allow. Mrs Walsh continues to take samples from the upper parts of the Red and White Volta Rivers during the wet season. Fish Drift Net sampling did not start in Ghana until July 1976 due to the lack of nets.
The techniques described in the Protocol appear to be working well and the three teams seem to be producing comparable results. There is a danger that with time, local variations will become established in the methods used. This tendency could be reduced by arranging for the teams to work together in the field or for an independent worker to visit each team at twelve to eighteen-month intervals. It has already been arranged that the monitoring teams should regularly compare laboratory methods and check identifications.

Trials with three types of artificial substrate were made by the O.R.S.T.O.M. team and the results are presented in the report of DeJoux and Venard (1976). Their findings were compared with those of the I.A.B. team during the monitoring meeting in Accra. It was agreed that the big disadvantage of the basket and stone method was that the baskets and stones were frequently stolen by local villagers. The concrete blocks, while less efficient, fauna samples were not stolen so frequently. It was, therefore, decided to adopt the concrete block method for the monitoring.

For convenience the results of the drift sampling are usually presented as numbers of animals per litre of water supposedly passed through the net and the Surber samples as numbers of animals per square metre of the river bottom. Neither technique actually samples with such accuracy and the figures should be accepted solely as convenient forms of presentation.

4. RECORDING FORMS AND DATA HANDLING

Final versions of the recording forms were devised at the meeting in Accra in July 1976. These forms have now been printed in Geneva and supplied to the monitoring teams. Data recorded on the various types of old and local forms have been transferred to the new forms. Accumulated data has been stored in the WHO computer in Geneva. Provision has been made for circulating monitoring information to all the monitoring teams on a three-monthly basis.
Discussions between the monitoring teams, Dr Pugh Thomas and the OCP statistician, Mr J. Duppenthaler, are taking place as to how the data may best be analyzed.

The preliminary analysis of some data collected by Dr S. Frost in the summer of 1974, indicates that rivers with similar water regimes have very similar faunas and that it may therefore be possible to compare such rivers directly. Care, however, must be taken when comparing dissimilar rivers or rivers at different seasons (see section 8 of this report).

5. **THE MONITORING OF THE BAGOU AND OTI RIVERS**

Both the Bagoué and Oti Rivers are in Phase III areas of the Programme and neither river will be treated with pesticide until 1977. They thus represent sources of data on rivers in the Programme Area which have not been treated. It should be possible to demonstrate any effects of Abate on the fauna of these rivers when treatment started. The importance of carrying out the full monitoring programme, whenever possible at these two sites cannot be over-emphasized. Both the O.R.S.T.O.M. and I.A.B. teams have information on untreated rivers to the south of the Programme Area. This in itself means that data from them is not directly comparable with that from the treated rivers. The importance of the Oti and the Bagoué should be emphasized to the respective field teams.

6. **RIVERS IN THE NIGER CATCHMENTS**

Rivers draining into the Niger and the Niger itself differ both chemically and biologically from rivers in the Volta basin. The monitoring of rivers in the Niger system was discussed at the monitoring meeting held in Accra in July 1976 and it was suggested that samples be taken from a Niger tributary to the East and to the West of the Zone of Inundation. Ways of taking such samples are being investigated. Both rivers would be in Phase III areas and if monitoring could be started in the near future it would be possible to gather data on a before and after treatment basis.
7. **24-HOUR SAMPLING BEFORE AND AFTER TREATMENT**

Professor H.B.N. Hynes has suggested that drift samples be taken both above and below a treatment point on each major river at hourly intervals, starting 24 hours before treatment and continuing for at least 24 hours after treatment. Some work has been done on this matter by Claude Dejoux of O.R.S.T.O.M. Professor Hynes argues that data of this type could well be used by people or organizations opposed to the Control Programme. In this, I am sure that he is correct. Neither the O.R.S.T.O.M. nor I.A.B. monitoring teams believe that they have the time and resources to do this work either in the field or in the laboratory. If it is to be done then special provision must be made for it. It might well be more effective to make an intensive study of one river rather than to spread these resources over several waters.

8. **THE EFFECTS OF ABATE ON RIVER ECOLOGY**

(a) **Drift**

Both the I.A.B. and O.R.S.T.O.M. teams have noticed an increase in the number of invertebrates in the drift samples immediately after treatment. It is not known whether this increase is due to animals which have been killed by the treatment and thus have been casually released into the flow or whether the increase is due to animals which have released their hold on the substratum in order to drift downstream out of a zone of adverse water conditions. An attempt should be made to resolve this problem.

(b) **Long-term effects of Abate on Invertebrates**

On page 11 of their annual report for 1976 the O.R.S.T.O.M. team compare the invertebrate fauna of the untreated River Maroue with that of four treated rivers in the OCP area. From the data it would appear that Abate does have a long-term effect on the invertebrates of treated rivers. Some caution is necessary when looking at this table. The Maroue is to the south of the Programme Area and might well be a river in which the fauna is naturally richer than in those rivers further north. Conversely, the rivers where there has

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1 Such a situation is hinted at on page 9 of the O.R.S.T.O.M. report where it is said that the fauna is particularly abundant.
apparently been the greatest reduction in the fauna are those which have received the largest concentrations of Abate.

As stated above, the Bagoué and Oti Rivers are both in Phase III and will not be treated until 1977. When treatment starts it should be possible to demonstrate the presence or absence of an effect of Abate on the fauna. If it can be arranged it would almost certainly be useful to have data from the two rivers on a more frequent basis than normal immediately after treatment. A fortnightly sequence is suggested.

At present, data for inspection is only available from July 1975 to March 1976 and it is thus not possible to compare rivers for the same month in successive years. The danger of comparing river data from the same river, but for different months, is shown for the mean numbers of Baetidae caught in the day drift in the Leraba River.

<table>
<thead>
<tr>
<th>Month</th>
<th>7/75</th>
<th>8/75</th>
<th>9/75</th>
<th>10/75</th>
<th>11/75</th>
<th>12/76</th>
<th>1/76</th>
<th>2/76</th>
<th>3/76</th>
<th>4/76</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animals</td>
<td>31.3</td>
<td>23.0</td>
<td>3.0</td>
<td>19.7</td>
<td>5.0</td>
<td>7.3</td>
<td>4.0</td>
<td>4.7</td>
<td>0.6</td>
<td>1.0</td>
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<tr>
<td>in drift</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Similarly, if populations of Baetidae in different rivers are compared it can be seen that it is difficult to make valid comparisons from one river to another.

<table>
<thead>
<tr>
<th>River</th>
<th>Leraba</th>
<th>Comoé</th>
<th>Bandama</th>
<th>Nzi</th>
<th>Bagoué</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>31(7/75)</td>
<td>25(8/75)</td>
<td>1200(3/76)</td>
<td>68(11/75)</td>
<td>20(1/76)</td>
</tr>
<tr>
<td>Mean of day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>drift &amp; date</td>
<td>7/75</td>
<td>8/75</td>
<td>3/76</td>
<td>11/75</td>
<td>1/76</td>
</tr>
</tbody>
</table>

Recent work at Salford University, indicates that some of the rivers have very similar characteristics and it may in future be possible to compare the ecology of similar rivers.

An attempt was made to see if there was any apparent shift in the ratio of pollution sensitive to pollution resistant species. This attempt was made on a very subjective review of the data. No easily visible change in the ratio could be seen. For instance the number of Baetidae in relation to the other.
Ephemeroptera does not appear to have increased in the day and night drift samples. There does not appear to have been an easily demonstrable increase in the number of chironomidae in either the treated or untreated rivers. There are certainly seasonal changes but the overall size of the population does not appear to change. In temperate rivers the Plecoptera are pollution sensitive, unfortunately Neoperla is of very sporadic occurrence in rivers in the Programme Area and it is not possible to use it as a pollution indicator and so not possible of the effect of Abate on non-target organisms. Similarly, the Oligochaetes, generally a pollution-resistant group, occur frequently and cannot be used to show an increase in a pollution tolerant group.

In the near future easily inspectable data will additionally be available for the rivers in Upper Volta and in Ghana. It will also be available for twelve or more months. This will not only make the analysis of invertebrate data easier, it will also make the interpretation much more objective.

(c) The Effects of Abate on the Fish of treated rivers

Dr B. Roman in his report on the fish of Upper Volta and Dr C. Leveque in the Annual Report of the O.R.S.T.O.M. team at Bouaké, both state that it is not possible to demonstrate any effect of Abate on the fish of treated rivers.

Full data on all the rivers being monitored for fish is not yet available but Figure 1 shows the coefficient of conditions for selected fish in the River Leraba. Abate does not appear to effect this measure of fish health. In future, it will be possible to present such graphs for the more common fish on all rivers. Again, this will be particularly interesting for the Bagoué and Oti Rivers.

The table below shows the mean number of fish caught per unit effort for one species of fish in representative monitored rivers.
Figure 1

COEFFICIENT OF CONDITION - LERABA

ALESTES BAREMOZE

LABEO COUBIE

LABEO SENEGALENSIS

EUTROPIUS MENTALIS

ALESTES NURSE

ALESTES RUTILUS
Table 1

<table>
<thead>
<tr>
<th>Species</th>
<th>Alestes</th>
<th>Baremoze</th>
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</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>River Leraba</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug. 1975</td>
<td>7.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Nov. 1975</td>
<td>5.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Feb. 1976</td>
<td>9.5</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>0.3</td>
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</tr>
<tr>
<td>River Comoe</td>
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</tr>
<tr>
<td>Jul. 1975</td>
<td>5.6</td>
<td>3.3</td>
</tr>
<tr>
<td>Oct. 1975</td>
<td>8.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Jan. 1976</td>
<td>7.8</td>
<td>6.3</td>
</tr>
<tr>
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<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>River Bandama (at Niaka)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 1975</td>
<td>65.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Aug. 1975</td>
<td>72.3</td>
<td>16.2</td>
</tr>
<tr>
<td>Oct. 1975</td>
<td>140.6</td>
<td>46.9</td>
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<tr>
<td>Jan. 1976</td>
<td>37.0</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>11.9</td>
<td>24.0</td>
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<tr>
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<td>No data</td>
</tr>
<tr>
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<tr>
<td>River Bagoué</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 1975</td>
<td>10.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Sep. 1975</td>
<td>0.9</td>
<td>0.5</td>
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<tr>
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</tr>
</tbody>
</table>
| From this table it can be seen that in the Leraba and the Comoe there is very little fluctuation in the numbers of small fish. In the Bandama at Niaka there is a large peak of small fish in October 1975. This could be due to migration. It emphasizes the danger of comparing the data of one sampling with that immediately preceding it. Annual comparisons are probably much more reliable. Again, data for the Oti, a large permanently flowing river as yet untreated will be particularly interesting. It should be noted that even early in the Programme the population was made up largely of small fish. As more data becomes available it will be important to establish the size ratios of the fish caught in order to counter possible fishermans' claims of having killed "all the large fish".

Table 2 shows the mean weights of Alestes Baremoze caught in the same rivers as in Table 1.
Table 2

<table>
<thead>
<tr>
<th>Species</th>
<th>Alestes baremoze</th>
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</thead>
<tbody>
<tr>
<td>River Leraba</td>
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</tr>
<tr>
<td>Date</td>
<td>Wt.grms</td>
</tr>
<tr>
<td>8/75</td>
<td>287.2</td>
</tr>
<tr>
<td>11/75</td>
<td>173.5</td>
</tr>
<tr>
<td>2/76</td>
<td>975.9</td>
</tr>
</tbody>
</table>

The weights are very variable and this applies to the treated rivers and to the untreated River Bagoué. Weight fluctuations are probably linked to the breeding cycle and a knowledge of the biology of the more important species will be needed when interpreting this data. Again, comparisons on an annual basis are likely to be more reliable than those on a short time scale. It would also be beneficial if the sampling months for each river could be kept the same.

Vidy in O.R.S.T.O.M., Report No.2, 1976, stresses the fact that many insectivorous fish eat large numbers of terrestrial insects which fall into the rivers. The importance of this source of food should not be under emphasized as it may buffer the fish against loss of food should Abate or other insecticide seriously reduce the aquatic invertebrate population.

(d) Data Analysis

As stated in 3, above, the analysis of data should become increasingly effective as more past material is transferred to the WHO computer and as further information comes in from the field. At present the diffuse nature of the records makes their interpretation very difficult.

(e) The Interpretation of Monitoring Data

The material collected in the field should make it possible to demonstrate that changes have or have not occurred in the various rivers after the start of the Control Programme. It will be more difficult to gauge the significance of such changes. Essentially, when added to a river, Abate is a pollutant. It may, therefore, be possible to gauge the ecological significance of changes in the Control Programme Area rivers by using methods developed for estimating pollution damage in temperate rivers.
Such techniques should be tried using the data which has already been collected in the field and a review of work on polluted rivers in the tropics should be done. Final interpretation of possible ecological changes will probably depend on a combination of the use of temperate methods modified in the light of such pollution information as may be available for the tropics and a progressively increasing incorporation of knowledge from the monitoring itself.

Guidelines on this subject are, however, desirable against the possibility of the criticism of the Programme causing environmental damage.

9. OTHER MATTERS

(a) Primary Production

As stated in an early form of the Protocol for Aquatic Monitoring the phytoplankton is an important source of primary production. This, together with the epiphyton probably contributes most of the primary production in the rivers in the Programme Area. Work on these two plant communities in the field is very difficult and needs specialized equipment and training. Consequently none is being done. The "Monitoring Programme" is open to serious criticism in this respect. Laboratory trials on the effect of Abate on phytoplankton cultures would be relatively easily done and it is suggested that a preliminary series of such experiments be initiated.

(b) Duration of the Monitoring Programme

The monitoring programme has been in effect, in operation for just over one year. There is a possibility that Abate is having an effect on the invertebrate fauna of the treated rivers. Experience with other pesticides indicates that it may take several years for such effects to manifest themselves fully. It is, therefore, desirable that at least for some rivers the monitoring be regarded as a long-term activity. The author of this report believes that if it is necessary to reduce the monitoring programme in the future it would be more appropriate to reduce the number of rivers sampled regularly rather than to reduce the frequency of sampling on all rivers. Once an adequate background knowledge of the rivers has been obtained it should be possible to select representative rivers for continued intensive sampling.