Chapter 9
The Fish Monitoring Programme of the Onchocerciasis Control Programme in West Africa: a Model for Fish and Fisheries Preservation in the Face of Development

E.K. ABBAN[1], L. YAMEOGO[2], D. PAUGY[3], K. TRAORE[4], M.E. DIOP[5] and E.M. SAMBA[2]

[1] *Water Research Institute, PO Box 318 Achimota, Ghana,* [2] *Onchocerciasis Control Programme, 01 BP 549, Ouagadougou 01, Burkina Faso,* [3] *ORSTOM, 213, rue Lafayette, 75480 Paris, France,* [4] *IDESSA, BP 633, Bouake, Côte d'Ivoire,* [5] *National ONCHO Team, Kankan, Guinée*

9.1 Introduction

Human onchocerciasis, or river blindness, is a filarial disease caused by *Onchocerca volvulus* which, in West Africa, is transmitted by the adult female of the blackfly, *Simulium damnosum* s.l. (Zimmerman *et al.*, 1992). It was common mainly along the fertile valleys of the watercourses and was not only a major public health problem but also an obstacle to the socioeconomic development of the infested areas.

In 1974, the concern of the governments of seven of the most affected countries in West Africa (Benin, Burkina Faso, Côte d'Ivoire, Ghana, Niger, Mali and Togo), supported by the World Health Organization (WHO), the United Nations Development Programme (UNDP), the Food and Agriculture Organization of the United Nations (FAO), the World Bank and many donor countries and institutions, culminated in the launching of the Onchocerciasis Control Programme (OCP) (WHO, 1985). Following requests for membership made by four other countries in the subregion (Guinea, Guinea-Bissau, Senegal and Sierra Leone), the Onchocerciasis Control Programme in West Africa has since 1984 involved 11 countries and has now been effectively controlling the reinvasion of the original area by exogenous blackflies.

The principal objective of the OCP has always been to reduce the incidence of the disease to a level at which it will no longer be a major public health problem or an obstacle to socioeconomic development. Because of the absence of an effective drug for mass treatment of infected humans, it was decided to apply larvicides on the fast-flowing sections of the watercourses where the aquatic larval stages of the vector develop. The very short larval life of the blackfly led to the choosing of weekly larvicide applications to eliminate transmission of the filarial worm by the blackflies.

It was also emphasized that this larviciding would need to last for 20 years (WHO, 1969; Davies *et al.*, 1978) to permit virtual elimination of *O. volvulus* from the human population. With such an expanse of aquatic environment to be exposed to regular larviciding, the concerns of the participating countries and the donors were as numerous as they were diverse. Therefore, the sponsoring agencies instituted several checks at different stages of its operations. Principally, these included the criteria for selecting insecticides for operational use (Lévêque *et al.*, 1979; Yaméogo *et al.*, 1991a), the process of identifying which of the approved larvicides would be used in a particular week's treatment (Guillet, 1991; Hougard *et al.*, 1993) and the long-term monitoring of aquatic fauna (Dejoux, 1980; Lévêque *et al.*, 1979, 1988; Paugy, 1983; Yaméogo *et al*, 1988; Yaméogo *et al.*, 1991b; Hugueny, 1992; Yaméogo, 1994).

This chapter presents an overview of the current status of the fish monitoring component, its objectives, rationale, methodologies and results in order to show the role that different factors could play in the modification of the structure and composition of the fish populations.

9.2 The fish monitoring programme and practice

9.2.1 *Basics*

The concepts and issues considered in evolving the fish monitoring programme and protocol prior to the commencement of the OCP larviciding have remained valid till now. Lévêque *et al.* (1979) outlined the issues and established the programme and protocol within two years of practice. However, the programme has been dynamic and refinements and standardization have continued as a consequence of accumulated data and a better understanding of the ecosystems involved. For example, Paugy (1983) made a comprehensive review of aspects of the monitoring practice and interpretation of data. However, the primary objectives of the monitoring have remained valid after 20 years of OCP operations. These briefly are:

(1) To detect any indications of any long-term effect of larviciding on fish populations and communities, and thus provide warning to larvicidal activities of the OCP, should any adverse effect be noted
(2) To assure all concerned that care was being taken not to unduly interfere with fisheries of the rivers as they form a major economic activity base for several communities in the OCP area

The rationale behind the objectives, as indicated by Lévêque *et al.* (1979) and Lévêque (1989), are that long-term exposure of fish populations to even sub-lethal concentrations of insecticides could physiologically influence the life cycles of populations or affect eggs and juveniles. In either or both cases, fish abundance would be expected to decrease in the long term. This could be for the whole fish community or particular species. Secondly, it could be possible that larviciding may affect the food chain of fish, leading to reduction. Such a situation could, in the long term, be observable by a change in the 'condition' of species affected (Lévêque, 1989; Yaméogo *et al.*, 1993a). It is for the above reasons that, with particular reference to fish, one of the criteria for the selection of a larvicide for operational use has been that the larvicide, at the operational dosage, should have no direct or indirect impact on the life cycle or activities of fish (Lévêque *et al.*, 1979; Lévêque, 1989; Hougard *et al.*, 1993).

9.2.2 *Manpower*

For reliable data collection over the OCP area, appropriate human resources had to be available. Initially, the fish monitoring exercise was undertaken by two institutions: an ORSTOM hydrobiological laboratory in Bouaké, Côte d'Ivoire, and the Institute of Aquatic Biology, in Ghana. Over the years, the two institutions, with great assistance from the OCP, have provided training grounds for personnel from all programme countries to constitute national monitoring teams. The national teams continue to expand their knowledge through the OCP by mutual interactions and exposure to international experts. A group of international experts, constituting an independent 'Ecological Group' meets every year to evaluate the results of the national hydrobiology teams and advises the OCP on monitoring procedures and on safe insecticide screening and use (Cummins, 1985).

9.2.3 *Selection of stations*

The locations of the sites which have been used as regular monitoring stations are shown in Fig. 9.1. The major criteria for their selection were: accessibility all year round, suitability for the deployment of sampling gear and availability of hydrological data (Lévêque *et al.*, 1979; Lévêque, 1989). While theoretical suitability of a site was based on map location, practical knowledge of stations was considered for their selection.

9.2.4 *Sampling methods*

Details of the methods used for OCP fish monitoring have been described by previous authors (WHO, 1976, Paugy, 1983).

A basic fish sample for OCP fish monitoring consists of fish caught in a standard battery of gill nets. Initially the battery consisted of five mesh sizes, 15, 20, 25, 30 and 40 mm). During the late 1980s, these were augmented to include three more mesh sizes (12.5, 17.5 and 22.5 mm). Each net has a surface area of 50 m^2 (2 m deep and 25 m long).

Usually a sample is the catch made by deploying two batteries of nets for two consecutive nights. For comparison and standardization, results are expressed as number of fish caught per 100 m^2 of gill net per night or catch per unit effort (CPUE). Standard data sheets are available to all teams to record CPUEs per mesh size of net, per species and a cumulative CPUE per sample at a station.

After individual identification, the length and weight of fish are measured as well as sexing and determination of gonad stage. Other biological parameters of individual

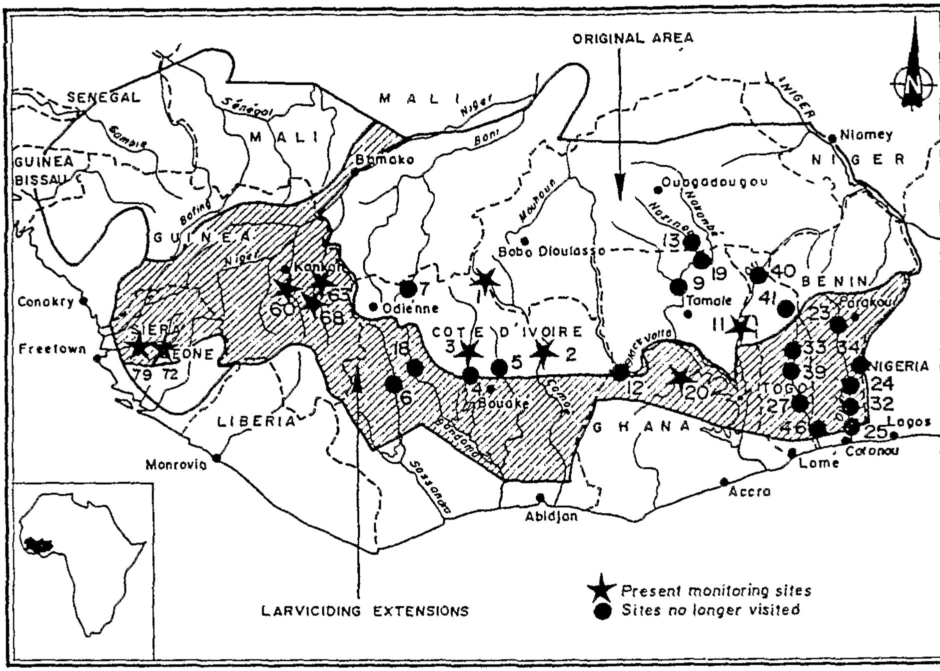

Fig. 9.1 The Onchocerciasis Control Programme in West Africa as accepted by the Joint Programme Committee (JPC) in 1984. Location of the fish monitoring sites as at 31 December 1993. (Key to monitoring stations: 1 = Léraba-bridge/Léraba; 2 = Gansé/comoé; 3 = Niaka/White Bandama; 11 = Sabari/Oti; 20 = Asubende/Pru; 60 = Boussoulé/Milo; 63 = Mandiana/Sankarani; 68 = Baranama/Dion; 72 = Matotoka/Pampana; 79 = Magburaka/Seli.)

species such as the coefficient of 'condition' factor of species, gonadosomatic index of fish, length at first maturity and fecundity are also estimated from the sample. The estimation of the 'condition' of species is a basic requirement from all monitoring teams. This is because the 'condition' (K) is a mathematical expression of the well-being of a fish. The factor is thus used to assess the ecological suitability of an environment to fish. With reference to OCP larviciding therefore, it is paramount to follow the 'condition' of species as a summary assessment of the influence of environmental conditions on fish. Data obtained in the field are recorded on standard designed forms and sent to the OCP headquarters in Ouagadougou, Burkina Faso, where they are fed into a computer for later analysis.

In addition to data collected by the regular monitoring, it was realized at the beginning of the programme that scientific information on fish and their biology in the OCP area was generally limited. Therefore specific special studies were and are still made to provide background information to and aid the interpretation of the monitoring results. These have included studies on the short-term effects of various larvicides on fish, feeding habits, fecundity and biology of specific species (e.g. Paugy, 1978, 1980; de Merona, 1981; Abban and Samman, 1982; Albaret, 1982; Antwi, 1983; Antwi, 1987; Yaméogo *et al.*, 1991c, 1993a, 1993b).

9.2.5 *Sampling frequency*

The concept at the beginning of the programme was that the sampling had to be sufficiently frequent to make it likely to differentiate between natural and artificially induced changes in the fish populations. Thus, basically, a monthly sequence was established for all stations (Lévêque *et al.*, 1979).

Since 1985, sampling frequency for basic OCP monitoring data at most of the operational stations has been reduced to once every two months. The number of sampling sites has also been reduced, justified by accumulated data on stations, comparability of geographically close stations, expansion of programme area and resource availability.

9.2.6 *Hydrological regime*

In the whole OCP area, hydrology of most of the rivers is mainly characterized by a flood period from July–August to October–November with a peak in September, and a low-water period from January to June. The flood period is correlated mainly with high turbidity and conductivity values, with a decrease in pH values.

The discharges of the savanna rivers in the original programme area indicated low values from 1975 to 1978 (Niaka on White Bandama) and from 1982 to 1984–85 (Niaka on White Bandama and Oti at Sabari), periods which corresponded to the drought (Fig. 9.2). In tropical conditions, water volume is a limiting factor of production compared with temperate zones where temperature is the limiting factor. Welcomme (1985) showed that fish reproduction tends to be highly seasonal and correlated primarily with flood. It is therefore assumed that poor flood years will be followed by poor recruitment and then poor catches by gill nets.

9.3 Results and discussion

The data which will be analysed here are those recorded by the national hydrobiology teams which work under contracts signed with the OCP programme.

9.3.1 *Fish species richness*

At most of the monitoring sites, the number of fish species caught shows seasonal fluctuations with a maximum at low-water periods. These periods correspond to the maximum efficiency of the gill nets. All rivers show no evidence of a reduction in species richness (Fig. 9.3) after almost 20 years of larviciding in the original area of the programme and some seven years of larviciding in Guinea. Lévêque *et al.* (1988) reached the same conclusions after ten years of larviciding with Abate®, Chlorphoxim and *Bacillus thuringiensis* H-14. The same authors suggested that the total number of species could mask changes in species composition. However, results from all rivers did not show disappearance of species after 20 years of larviciding.

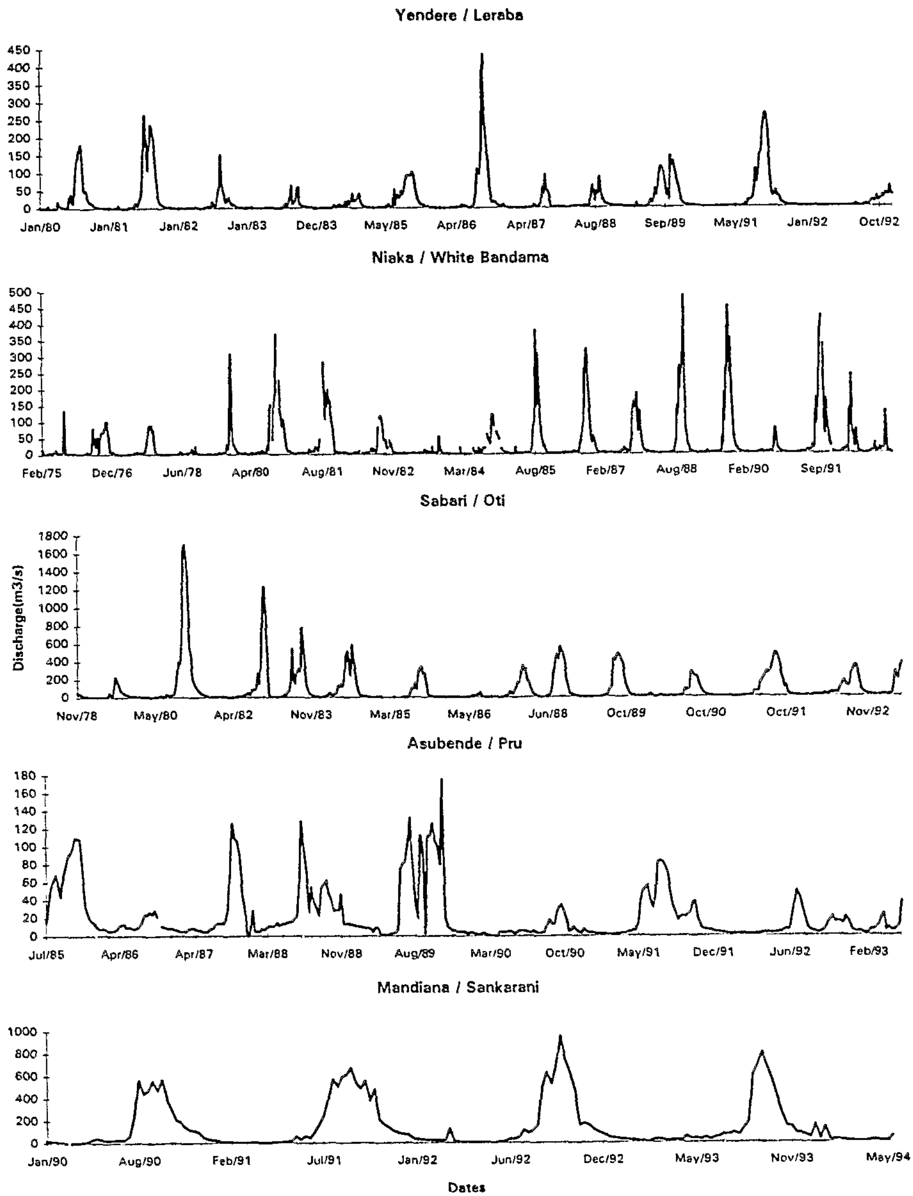

Fig. 9.2 Trend in discharge for some of the monitoring sites studied in this chapter.

9.3.2 *Species composition*

The data collected since the beginning of the monitoring make it possible to affirm that not all the stations are located in the same ecological zones or watercourses. The species composition and representative species therefore differ from one site to another (Fig. 9.4) but, on the stations covered by this report, *Petrocephalus bovei*,

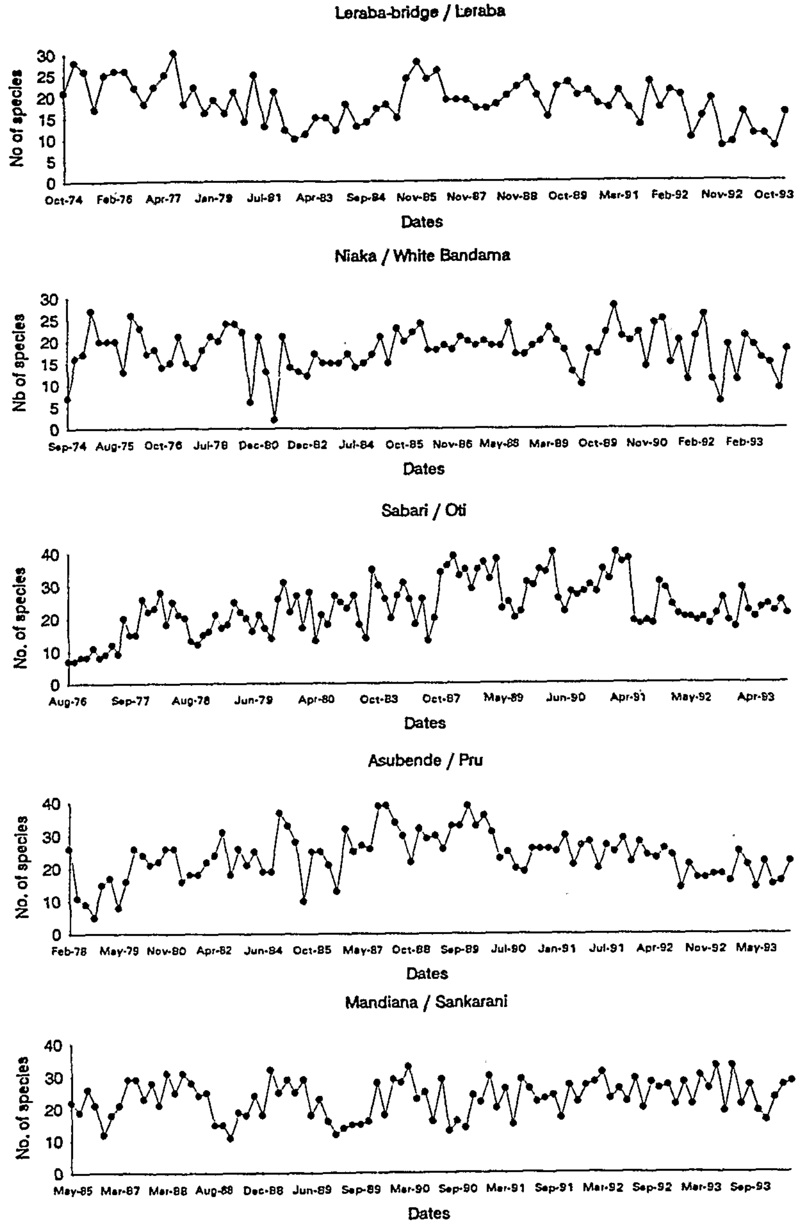

Fig. 9.3 Trend in the number of fish species per sample at different sampling sites during the monitoring period.

Brycinus macrolepidotus, *B. nurse*, *Schilbe intermedius* and *Synodontis schall* are the species which are encountered in most of the catches. *Brycinus leuciscus* and *Chrysichthys auratus* are virtually absent from Niaka on the White Bandama and Léraba-bridge on the Léraba while they are represented at the other stations.

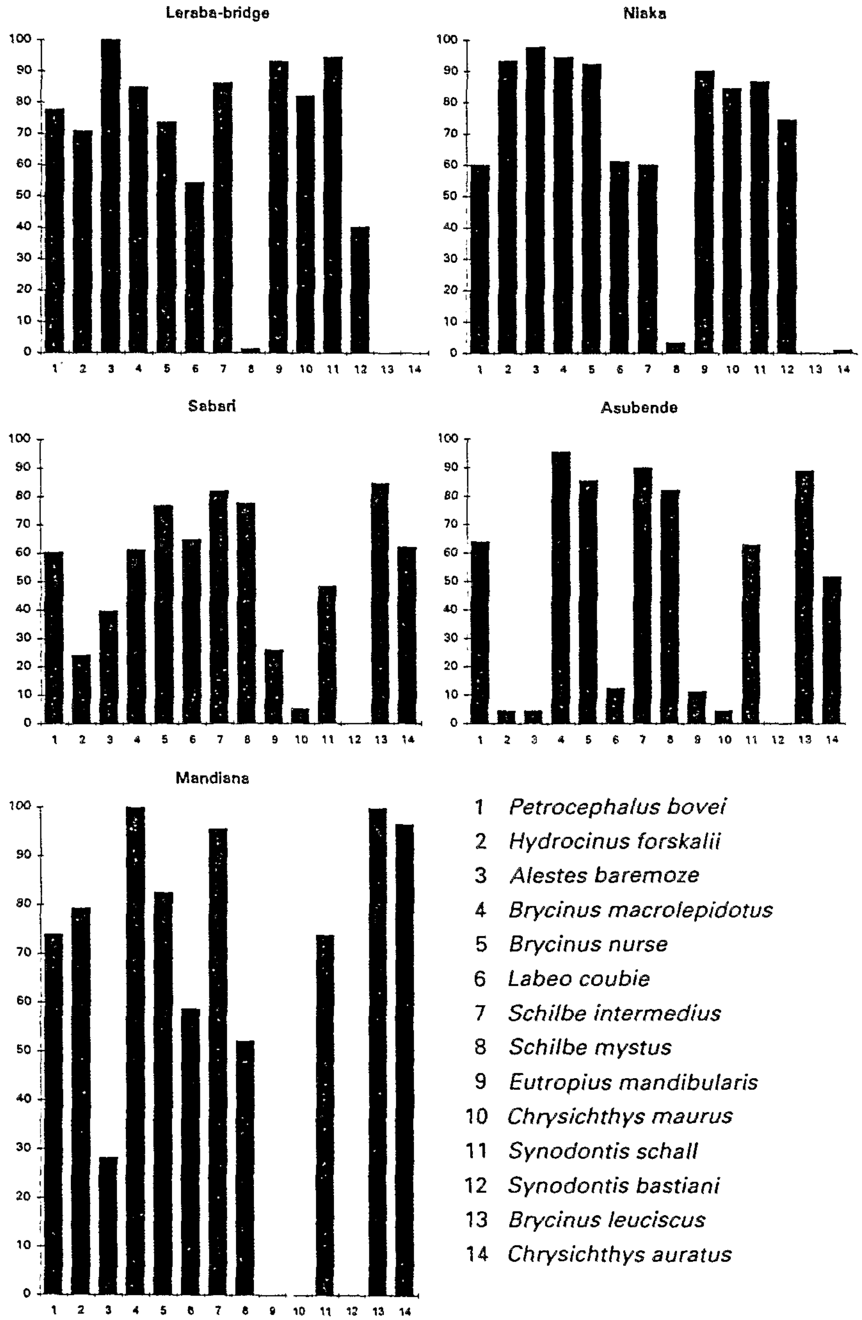

Fig. 9.4 Frequency of experimental catches of the principal species caught in gill nets at different monitoring stations.

9.3.3 *Fish abundance in experimental catches*

In the short term, the catches per unit effort (CPUEs) of fishing could be affected by the use of larvicides, the duration of the effect being dependent on the discharge and the nature and/or dosage of the larvicide (Abban and Samman, 1982; Yamégo *et al.*, 1993). It has been observed, just as for the richness, that the maximum CPUEs are recorded at the end of the high-water period (November to January).

Considering the experimental catches made at different monitoring stations and expressed as the mean CPUE for the standardized set of gill nets (Fig. 9.5), two phenomena are noted:

(1) A seasonal pattern with higher catches at the flood subsidence and lower catches during the high-water period
(2) In the long term, the catches indicate some fluctuations but the mean remains quite stable in most of the cases (Oti at Sabari, Pru at Asubende and Sankarani at Mandiana), a slight decrease is observed in the Léraba at Léraba-bridge and on the White Bandama at Niaka

The fluctuations in the abundance of fish in the rivers are related mainly to the hydrologic regime (Lévêque and Herbinet, 1980; Abban *et al.*, 1982; Lévêque *et al.*, 1988). In recent years, the great pressure exerted by fishermen, who are increasingly using fishing gears that are not very selective, has contributed to the impoverishment of the watercourses. In fact, at Léraba-bridge, where the number of inhabitants increased from zero in 1980 to 400 in 1993, the catches are less good (CPUE = 1482 g) than at 12 km downstream (CPUE = 7414 g) where there is still no village.

As regards catch composition, the data collected for almost 20 years do not indicate any disappearance of species. On the other hand, a dynamics of the fish, which is difficult to interpret, has been noted. The case of the species *Schilbe intermedius*, in the upper basin of the Léraba, is an illustration: after the start of the anti-blackfly control operations in 1975, this species decreased and, in 1978, disappeared from the catches (Fig. 9.6). This was thought to be the result of the temephos sprayings. However, while the programme activities had remained unchanged, in 1979 this species reappeared in abundance. A similar observation was made on the same species in the River Pru, Ghana, prior to the commencement of its treatment. *Alestes baremoze* presented a similar problem on the Bandama (Paugy, 1978). In these cases, it was observed that the population returned to their initial level when the hydrological regime became 'normal' after a period of disruption due to drought.

9.3.4 *Coefficient of condition*

Estimates generally show relative stability in the 'condition' (corpulence) of the principal fish species (Fig. 9.7). However, the values for individual species fluctuate around means which do not seem to have been appreciably altered over the years. The above suggest the availability of sufficient food and no alteration in the feeding habits of fish, both of which could be affected by the presence of 'excessive' amounts of

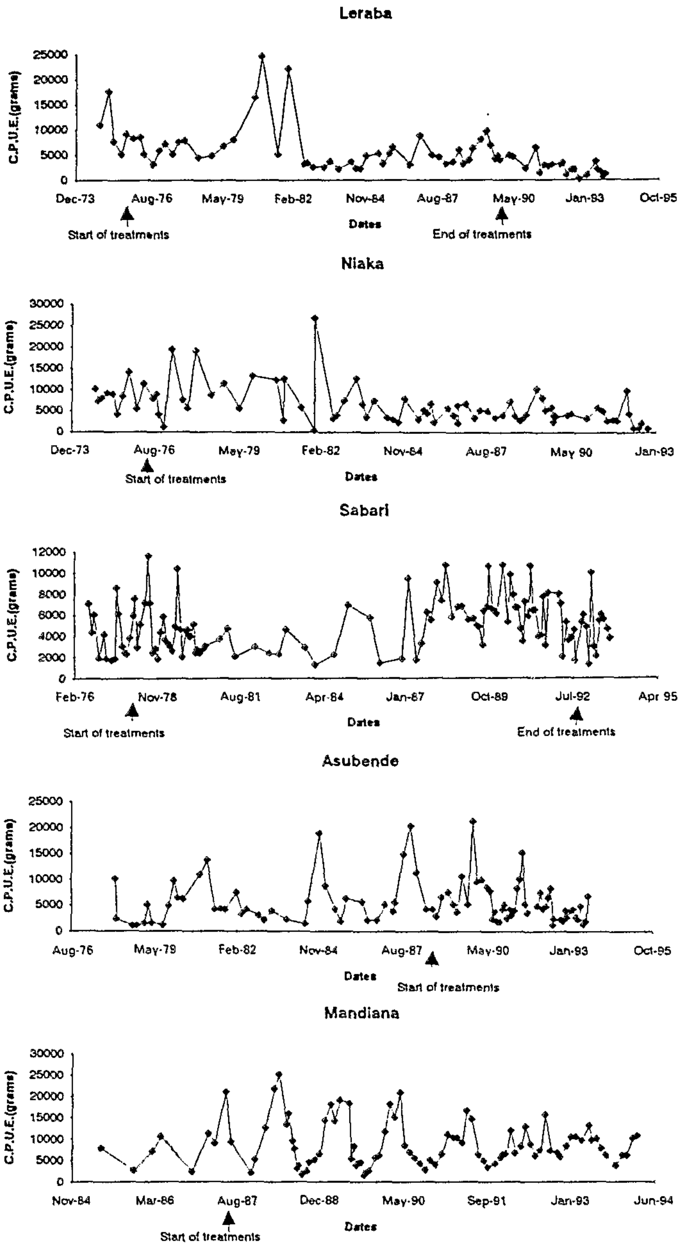

Fig. 9.5 Trend in mean catches per 100 m^2 of gill nets per night (CPUE in grams) at different monitoring sites.

insecticides (Abban and Samman, 1982). The fluctuations observed seem to be attributable to the influence of the reproductive cycle of the fish as well as the ecological effect of flood regimes (Paugy, 1978 and 1980; Lévêque and Herbinet, 1980; Lévêque *et al.*, 1988; Abban *et al.*, 1993). There is thus no evidence of a long-term modification in the 'wellbeing' of fish attributable to OCP larviciding.

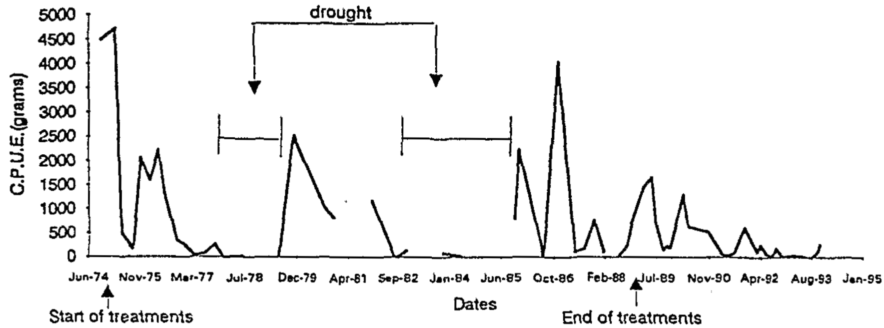

Fig. 9.6 Trend in catches per unit effort of *Schilbe intermedius* at Léraba-bridge/Léraba.

9.3.5 *Special and one-off studies*

Studies on a one-off basis are conducted on the biology of fish (especially feeding habits and brain cholinesterase activity of fish species) to ensure that there is no evidence of a strong impact of larvicides on these parameters.

As regards the food of fish, analysis of the stomach contents of different species from treated and untreated rivers did not provide evidence of an influence of larviciding on fish food (Vidy, 1976). For insectivorous species, this situation is attributed to the recolonization by entomic fauna of the treated sections of the rivers from untreated segments and tributaries (Yaméogo *et al.*, 1993a). Also, the capability of most of the fish species to adjust their feeding habits to new conditions was considered an important factor.

Toxicity of organophosphorus compounds is due mainly to their effect on the brain cholinesterase activity (Lévêque, 1989). Antwi (1985) found no inhibition effect in the brain AChE activity of fish (*Brycinus nurse*, *Schilbe mystus* and *Tilapia* spp.) in rivers treated for many years. However, caged *Tilapia zillii* showed a 20% reduction in the brain AChE activity five hours after Chlorphoxim treatment.

These studies indicate therefore that there is no evidence of a long-term impact of larviciding on the biology of fish in the watercourses treated by the programme.

9.4 Conclusion

The biological monitoring programme developed and instituted by the OCP gives an overview of fish populations in the rivers affected by the larviciding activities. After almost 20 years of monitoring, the results show that apart from the larviciding, other different factors (hydrological regime, human activities) have to be taken into consideration in order to understand the situation.

In fact, there has been no evidence of fish mortalities due to the use of blackfly larvicides at operational doses but fluctuations are observed in the abundance and richness of fish attributable to hydrological conditions and to the pressure exerted by

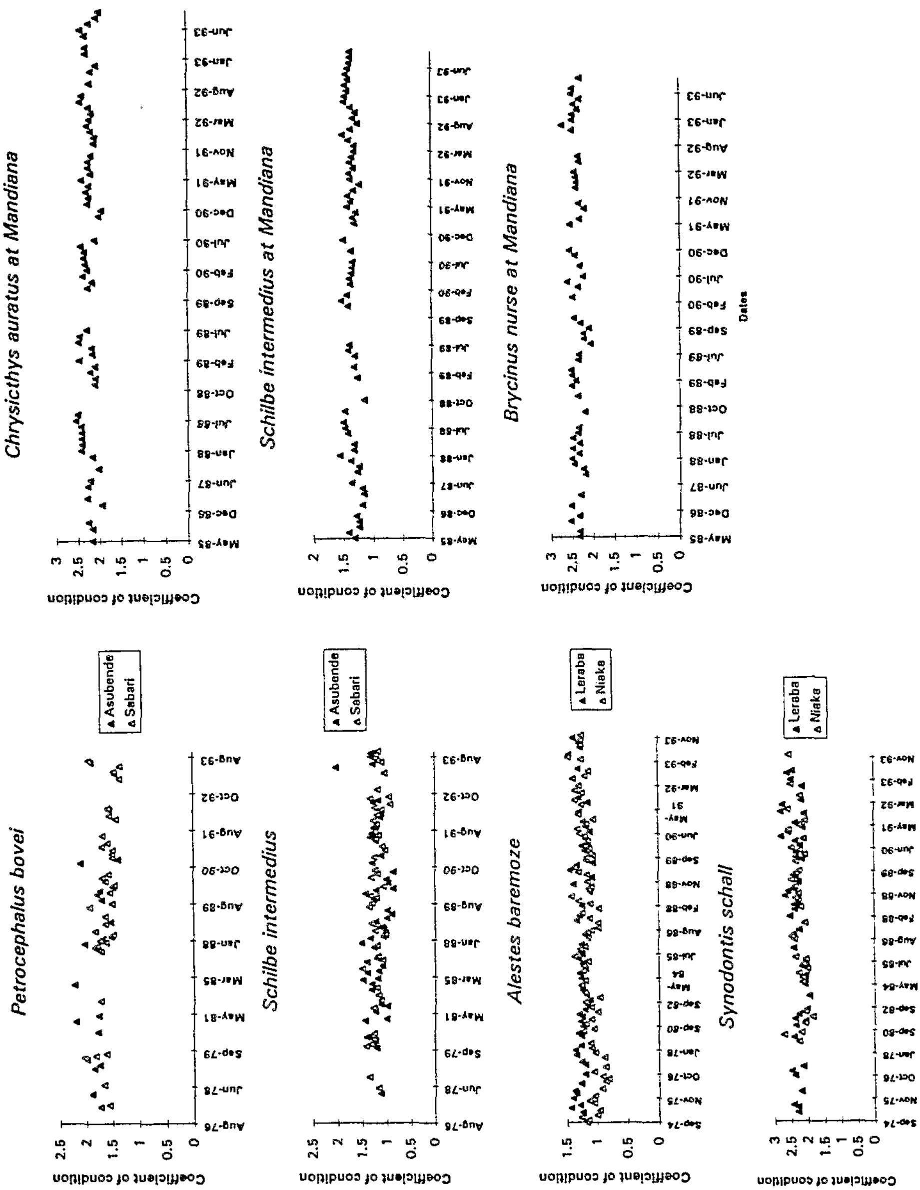

Fig. 9.7 Changes in the condition of the principal fish species at different monitoring stations.

local fishermen. As regards the condition of principal fish species, slight variations around a mean which remained quite stable have been observed, indicating the availability of food for the fish despite the use of different larvicides to control blackfly larvae. It is concluded therefore that the impact of human activities and that of drought seem to have more adverse effects on fish populations than that of the OCP's larviciding.

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