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Life after lakes: the ecology and management of the water distribution network

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Abstract

The fauna of water distribution is rarely studied, and then often only taxonomically. This paper describes an investigation into the community composition of the mains and the extent to which this is dependent upon the source of water. Slow sand filtration results in lower quantities of organic particulate material and organisms passing through into supply, rather than rapid gravity filtration, and the community is smaller and of different structure. A marked change occurred in a system when the supply source was changed.

Introduction

The problem of animal infestations in water supply is widespread but little understood. Water Supply companies accept that animals do exist in the mains but only privately acceed to the scale of the problem. Despite water treatment, in supply areas where the water is from a surface source (river or reservoir derived) rather than from a ground source, there are invariably invertebrate infestations of the distribution system. These infesting invertebrates are known to exit at consumers' taps, sometimes in considerable numbers, leading to complaints which frequently result in bad publicity for the water undertaking concerned. Infesting animals may also cause taste or discolouration problems resulting from stained carapaces or frasse. The community present in the distribution system, is a mixed community dominated by meiobenthos, with a few species of 'surface organisms' that are pre-adapted to survive without light or airspaces. The source of infestations in the distribution system is usually benthic animals penetrating treatment works, surviving and breeding in the distribution system and thus establishing a population of a size which may lead to consumer complaints (Collingwood, 1970).

Available control methods, both physical and chemical, are successful locally, but fail to totally eradicate infesting animals once they are established in a pipe system. Reinfestation, particularly from dead ends (small diameter pipes which have no through flow) at the extremities of a system is common (Mitcham & Shelley, 1980).

There is a lack of correlation between animals penetrating treatment and those in samples from parts of the distribution system, (Greaves & Evins, 1972; Evins & Greaves, 1979; Barham, 1985) and Smart (1989) found evidence suggesting that the survival of animals in the system is influenced by the characteristics of the system rather than by the numbers penetrating treatment. Infestations are almost certainly self-sustaining, with animals feeding on iron bacteria lining the inside of the pipes and organic input through treatment (Collingwood, 1970). The various factors which may affect the presence and numbers of infestations are shown in Figure 1

In the U.K. during the 1950s and 1960s, attention focused on infestations of predominantly oligochaetes and *Asellus aquaticus*, which created serious problems in some systems (Kelly, 1955; Houghton, 1968). These were resolved by treatment using pyrethrin, which enabled the dosing of entire systems without interrupting supply to consumers. More recently, severe infestations involving the parthenogenetic chironomid *Paratanytarsus iniquilinius* Krüger (Williams, 1974), which reproduces as a pharate adult, have been a problem. These animals have also been controlled by pyrethrin (Burfield & Williams, 1975), and more recently permethrin, but infestations rarely appear to be

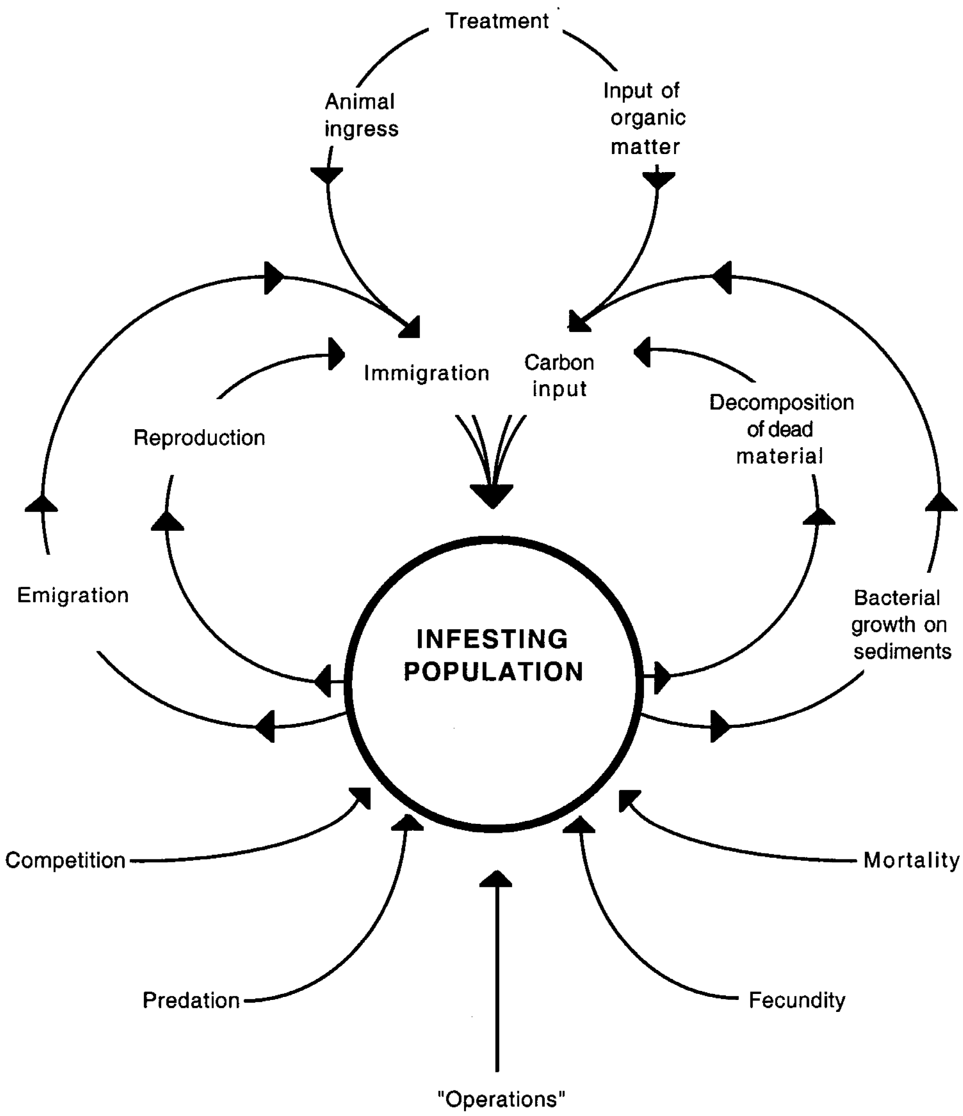

Figure 1. Model of the water distribution pipe ecosystem and factors influencing colonising populations.

cleared. Reinfestation by various taxa is frequent and can be rapid, with animals both surviving in the system and penetrating treatment playing a role.

The community in the study area of this project had moved away from the *Asellus*-dominated community of the 1970s and 1980s following frequent treatment of the water distribution system. What survived and, frequently flourished, was a simple community consisting of Chironomidae (including members of the *Parytanytarsus inquilinius* species complex; Oligochaeta (mainly Naids); Chydoridae; cyclopoid and harpacticoid Copepoda; Hydracarina; Halicaridae and some Mollusca. Many of these were able to penetrate treatment at some stage of the life cycle, to be present in large numbers, in water towers or service reservoirs or to live in low pressure areas of the system or dead-ends.

Unlike ground water (unless mixed with surface derived supplies), potable water in distribution systems from surface water generally has infestations. Penetration of rapid gravity filters (RGF) and slow sand filters (SSF) by invertebrates, algae and organic material provides both the benthic colonisers and a food source for the organisms in the system. Collingwood (1977) suggested RGF is more susceptible to penetration than SSF, and Rowlands (1982) indicated

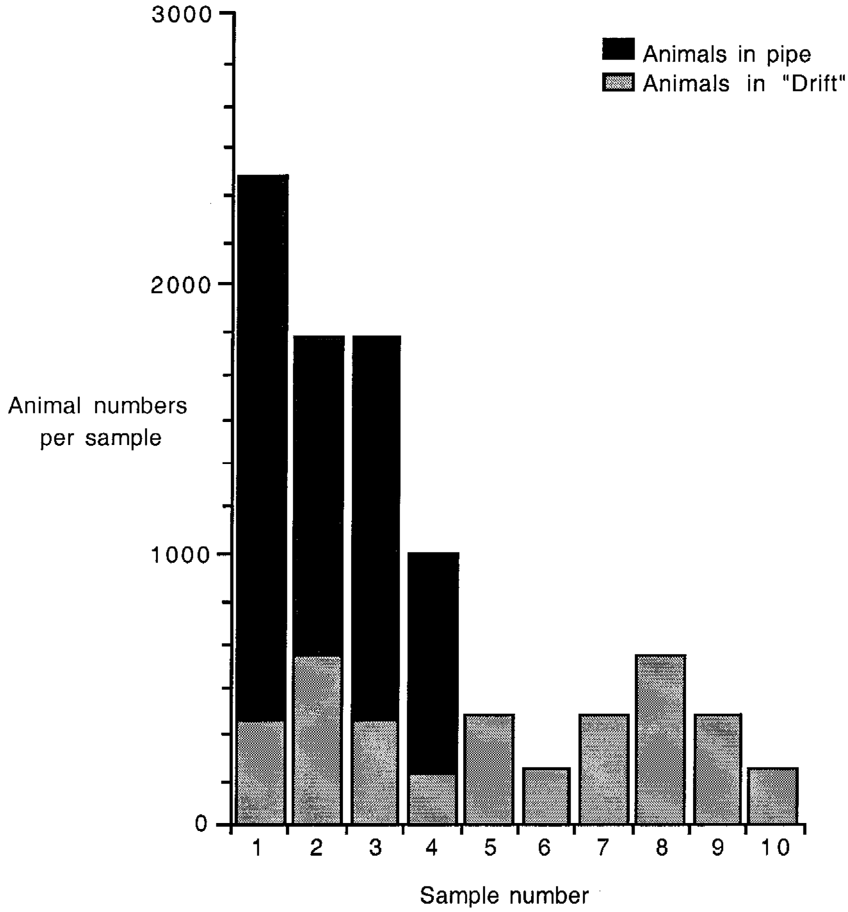

Figure 2. Diagrammatic representation of the assumptions behind the sampling strategy. As samples are removed from the main during a series of flushes, the animals present in the pipe itself are collected along with the 'drift' fauna. As the number of samples collected increases, the animals in the pipe are removed. Further flushing leads to the collection of animals at 'drift' density only.

that RGF final water quality is more variable than that from SSF. This confirms the observation of Houghton (1968) that a change from SSF to RGF led to an increase of available food in the final water, which resulted in a severe infestation of *Asellus aquaticus* in the South Essex system. The quantity of organic material used by animals in the system has not been established, but Collingwood (1970) calculated that at a treatment works experiencing an 'average' algal penetration, there will be sufficient organic material available per year to support a population of 4–5 *A. aquaticus* per metre length of pipe in a 1100 km system.

Sample methods

In the U.K., access to the potable water system is difficult. Access was achieved through fire hydrants situated on small diameter water mains close to the end of the distribution network. These could be opened to flush water through a 1 m-long mesh net pressures of over 7.0 ls^{-1}. Experimental tests showed that between three and five samples at appropriate sites would clear the animal community in the pipe, leaving only a residual number of animals that would have been carried in the water flowing through large diameter feed mains. These residual animals were considered to be 'drift'. Figure 2 shows how the sampling technique operated.

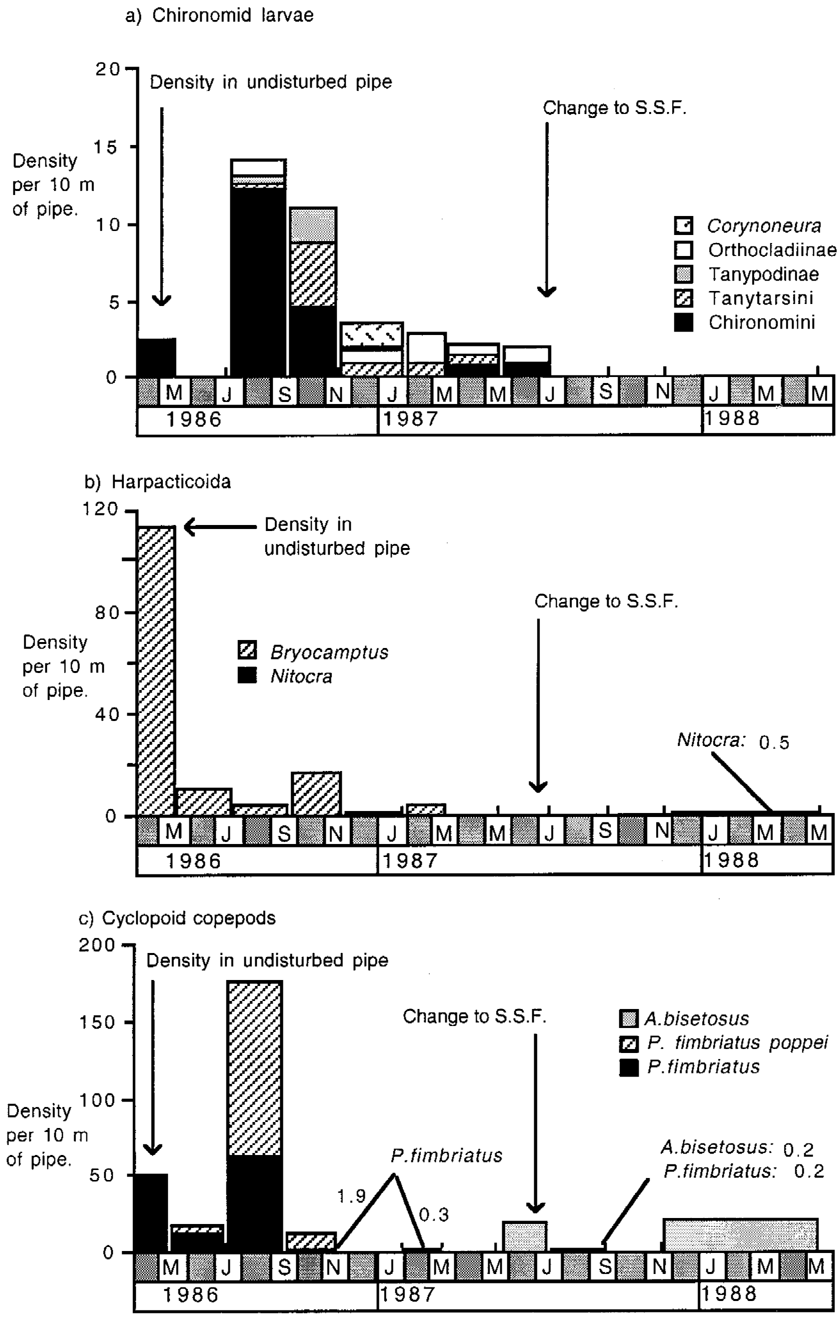

Figure 3. (a–c). Animal density per 10 m length of pipe in a rural site in Northamptonshire experiencing a change in source water treatment works.

Results

Regular sampling of sites at different frequencies over a two year period suggested that what is happening at each site is that a 'competitive lottery' occurs following community removal by flushing, rather than any form of predictable succession. The animals which arrive first are able to effectively exploit a surplus of resouces and continue to do so at the expense of other species. No pipe showed the same pattern of colonisation or community development with time, as any other pipe sampled. This concept of rudereal colonists

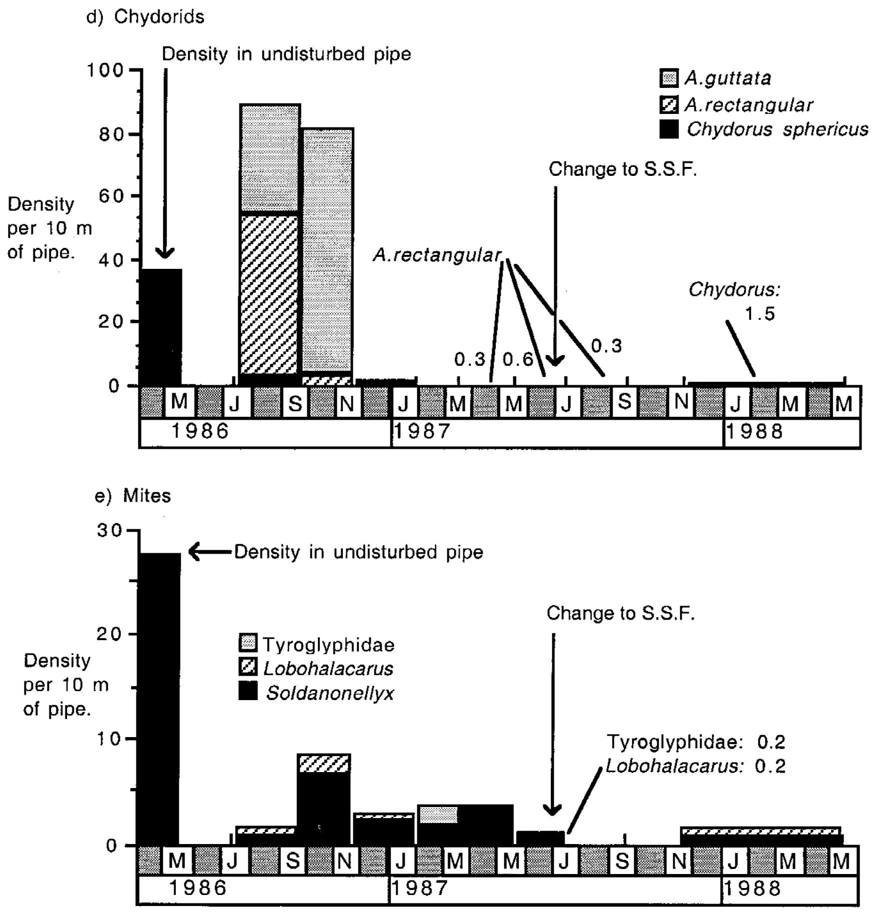

Figure 3. (d–e) Animal density in a 10 m pipe experiencing a change in source water treatment works.

was reinforced by the results at sites where the reservoir feed was switched from RGF to SSF. At these sites (Figure 3) it appeared that, following a switch to SSF, the species involved in recolonisation changed after the supply switch, particularly the copepods (Figure 3c), and, apart from tyroglyphid mites (Figure 3e), no major colonisation or recovery took place over the final six months when each site was left undisturbed.

In the situation where no switch of supply took place, recolonisation did occur in the final six months (Figure 4) and only harpacticoids appeared to be removed by repeated flushing (Figure 4b). Figure 4c shows the large number of *Megacyclops* nauplii, copepodites and adults that penetrated treatment at the rapid gravity filter and completed their life cycle in service reservoirs. This penetration at the end of the summer must have had a major influence on the biomass within the distribution system with dead animals providing a major food source for the ecosystem, and shows the importance of modern methods such as microstrainers to minimise zooplankton passage through treatment works in summer.

Discussion

Animals in the water distribution system will never be eradicated, but must be kept at levels which do not cause undue complaints from the consumer. The target for Water Companies is to manage storage reservoirs and treatment systems in such a way as to minimise the penetration of animals and organic material. The minimisation of the input to the ecosystem will enable costly chemical control methods, or wasteful physical methods such as flushing, to be kept as infrequent as possible.

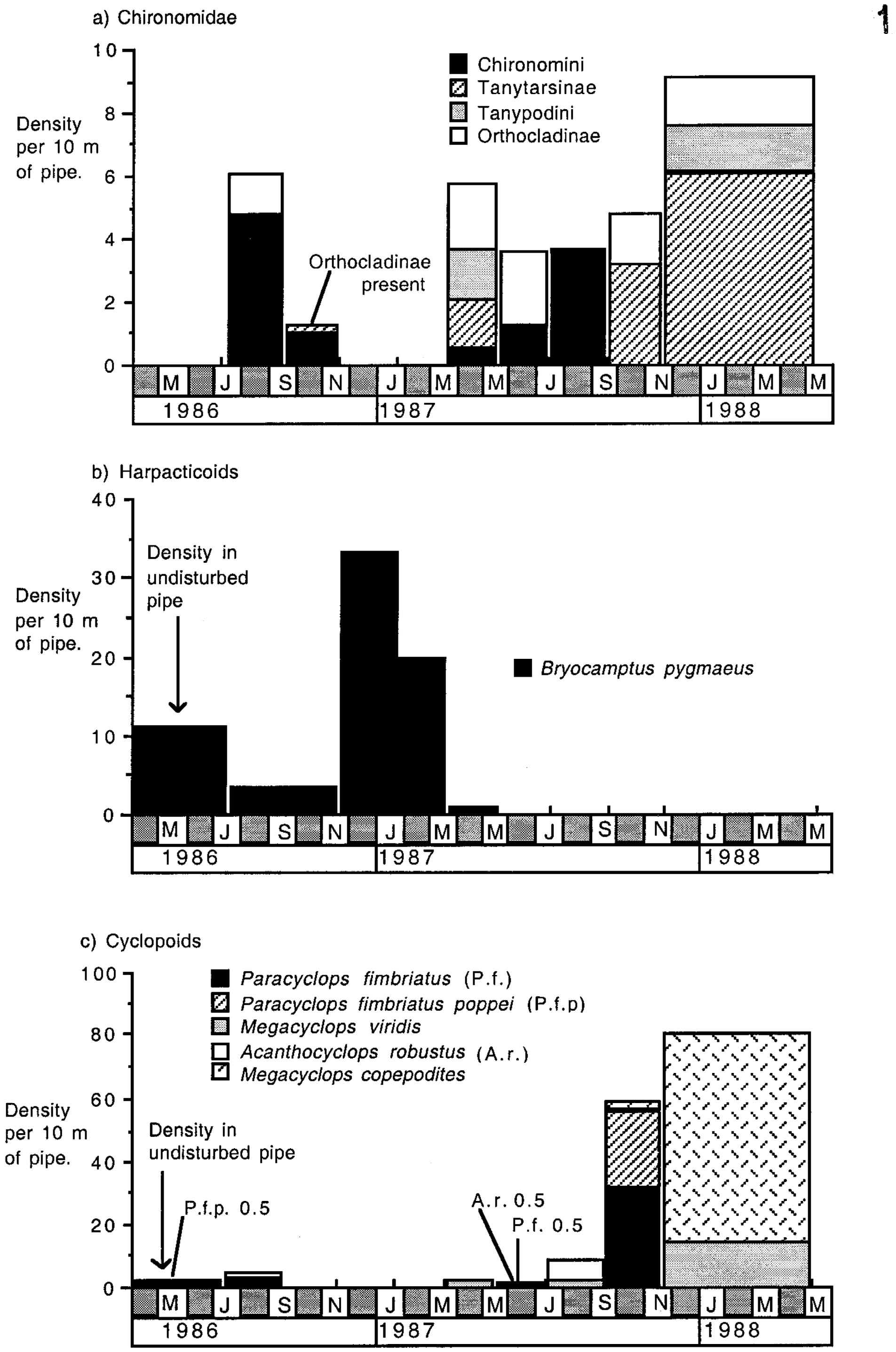

Figure 4. (a–c). Animal density per 10 m length of pipe in a rural site in Northhamptonshire not experiencing a change in source water treatment.

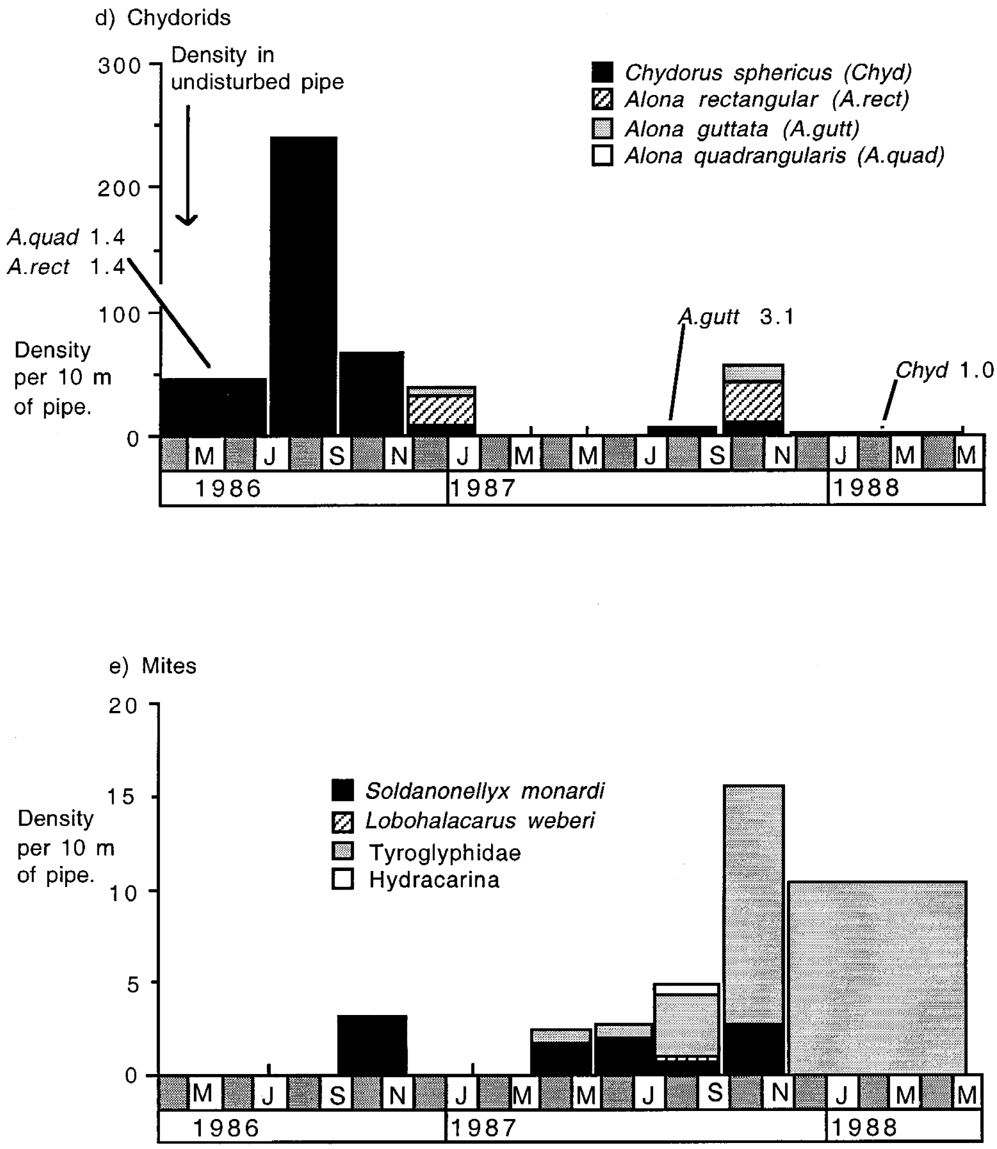

Figure 4. (d–e). Animal density per 10 m length of pipe with no change in source water treatment.

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