A Guide to DISEASE in EEL FARMS

Fisheries Research Division
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Introduction

THE rapid growth of the eel farming industry and the appearance of several diseases in eel culture establishments in New Zealand have necessitated the production of a quick guide to these diseases.

The organisms so far found in eel culture belong to only two groups—bacteria and protozoans. This is not surprising, as other groups of infectious agents either are not apparent in the wild or they require other animals in their life cycles, and these are not usually present in culture systems.

Though *Vibrio anguillarum*, which causes periodic large mortalities in the European eel, has been isolated only once in an eel in New Zealand, it is included in this booklet, as this species is a potential pathogen.

Of the parasites listed, only *Ichthyophthirius multifiliis* may be expected in eel farms under normal circumstances. The other species have entered eel farms in eels brought in from the wild some months after the maintenance of glass eels has been started. This underlines a very important point: **No matter how abundant elvers or eels may be, it is inadvisable to introduce them into a farm after they have been in natural freshwater systems for some months.**

This is because eels have a fairly diverse bacterial flora and parasitic fauna and thus disease-free or unparasitised eels are not common in the wild. Even when young, they may acquire a wide variety of infections, some of which are likely to flourish under farming conditions. Conversely, glass eels are almost totally free of infections.

An Outline of the Known Diseases in New Zealand Eel Farms

Site or signs	Organism	Treatment*
Gills only		
Small whitish cysts on gill filaments less than 6 mm in diameter	*Myxidium* sp. (page 13)	Isolate eels, impose strict hygiene, increase water flow; if feasible, dry out tanks, steam clean, or sodium hypochlorite scrub
Gills and skin		
Small whitish flaky areas on gills and along fins or fin margins	*Chondrococcus columnaris* (columnaris disease) (page 5)	"Furanace" (1 mg per litre) bath for 1 hour; oxytetracycline in feed at 75 mg per kilogram of eels per day for 10 to 12 days
Creamy spherical, often rotating organisms less than 1 mm in diameter	*Ichthyophthirius multifiliis* (white spot) (page 10)	A variety of treatments can be tried, but methylene blue (5 mg per litre) and formalin (30 to 40 ppm) long-term baths intermittently are recommended
Skin		
White blister-like cysts less than 8 mm in diameter	*Myxobolus* sp. (page 15)	As for *Myxidium* sp.
Red dots around mouth, bloody patches on fins, skin, or muscle	*Vibrio anguillarum* (vibriosis) (page 6)	Oxytetracycline in feed at 90 mg per kilogram of fish per day for 10 days; sulphamerazine in feed at 110 mg per kilogram of fish per day over 10 to 15 days; furazolidone in feed at 200 mg per kilogram of fish per day for 14 days; "Furanace" bath (0.5 mg per litre) for 5 hours
Bloody patches on the skin or muscle and often a reddening of the belly	*Aeromonas liquifaciens* (haemorrhagic septicaemia) (page 7)	Chloromycetin or oxytetracycline in feed at 50 to 75 mg per kilogram of eels per day for 10 days
Intestine		
Small blister-like cysts with occasional sloughing of mucosa	*Eimeria* sp. (piscine coccidiosis) (page 17)	Furazolidone in feed at 25 to 50 mg per kilogram of eels per day for 10 to 15 days; "Furanace" in feed at 2 to 4 mg per kilogram of fish for 3 to 5 days

* The text should be consulted before treatment is given.

Microbial Infections

Group: Bacteria, Myxobacterales.

Name: *Chondrococcus columnaris* (columnaris disease).

Signs: Columnaris disease starts as a whitening of the margins of fin tissue (Figs. 1 and 2). As the disease progresses the fin becomes damaged and irregular and collects detritus from the water. The fin may also become infected with *Saprolegnia,* which gives it a roughened and enlarged appearance. In advanced cases the infection erodes the muscle around the caudal fin and exposes the vertebrae. This causes the eel to swim awkwardly with excessive trunk movement. Columnaris also forms lesions on the gills and may be present systemically within the fish.

Fig. 1: Columnaris disease. Whitening and erosion of the fin soon after infection.

Pathogenicity: Moderate. There are several strains of *C. columnaris* with

Fig. 2: Columnaris disease. Characteristic erosion of the tail fin.

varying degrees of pathogenicity. Highly virulent forms will cause severe mortalities in 24 to 48 hours at a temperature of 21°C and be less severe at 16°C; the disease rarely occurs at temperatures below 15°C. Some strains are known to have very little pathogenic effect.

Microscopic examination of the edges of the lesions reveals large numbers of long (4 to 8 micrometres), slender bacteria, which are flexible and move by a gliding motion to form distinctive columns within 10 minutes.

A reservoir of diseased fish probably occurs in the wild, and infections in eel farms are likely to come from this source. The disease is widespread in fish culture where poor environmental conditions of low oxygen, accumulated waste products, and severe crowding favour the spread of the infection. Infected fish may not show obvious signs of disease at first, but later they may develop the characteristic lesions.

Treatment: Systemic infections can be controlled with "Furanace" (1 mg per litre) given as a bath for 1 hour. "Furanace" is eliminated from the eel tissues in less than 24 hours; so weekly or fortnightly treatments may be necessary if reinfection occurs. Oxytetracycline ("Terramycin"), in feed at 75 mg per kilogram of fish per day for 10 to 12 days or 3 days after mortalities have declined considerably, is also effective in controlling the disease.

Group: Bacteria, Pseudomonadales.

Name: *Vibrio anguillarum* (vibriosis, red pest, red sore, red disease, ulcer disease, boil disease, red boil disease).

Signs: The signs of *Vibrio* infection are similar to those of infections with *Aeromonas liquifaciens* and may be confused with them. Infected fish show loss of appetite, lethargy, and discoloured skin. Small red dots due to leakage of blood (petechiae) show around the mouth, and larger discoloured patches (ecchymosis) occur on the fins, particularly the anal and pelvic fins. Bloody abscesses may develop on the skin and muscle, but congested blood in the skin is the most pronounced sign (Fig. 3).

Pathogenicity: Not known, as the strain isolated from the wild has not yet been isolated from eel farms. However, similar signs to *V. anguillarum* infection have been reported in debilitated eels preceding death. The strain isolated from eels in the wild was apparently non-pathogenic, but disease symptoms have been induced by infecting young eels and stressing them.

Vibrio infections have been isolated mainly from marine or estuarine fish, as the bacteria are halophilic and cannot survive for long periods in fresh water. The occurrence of the bacteria in wild

Fig. 3: Vibriosis. Congested blood in the skin of an eel experimentally infected with *Vibrio anguillarum*.

eels in estuarine waters may serve as a reservoir to transfer the infection to elvers, which may then introduce the disease into a farm. The disease has also been suspected of entering a farm in marine fish used as food.

The resemblance of this bacterial disease, and the symptoms it produces, to *Aeromonas* and *Pseudomonas* infections makes isolation and identification of the organism in the laboratory the only positive way to identify vibriosis.

Treatment: Laboratory tests indicate that the following drugs may effectively control the infection: Oxytetracycline given in feed at 90 mg per kilogram of eels per day for 10 days or 2 to 3 days after the last death. Sulphamerazine is recommended at 110 mg per kilogram of fish per day over 10 to 15 days. Furazolidone given at 200 mg per kilogram of eels per day in food for 14 days. Nitrofurazone given in food at 560 mg per kilogram of fish per day for 4 days has been used successfully against vibriosis in yellowtails. A "Furanace" bath (0.5 mg per litre) for 5 hours has been found effective against vibriosis in rainbow trout.

Group: Bacteria, Pseudomonadales.

Name: *Aeromonas liquifaciens* (haemorrhagic septicaemia, red mouth, red plague, red pest, freshwater eel disease, hireaka).

Signs: Congestive lesions on the surface of the eel, especially a noticeable reddening of the belly (Fig. 4). It resembles the signs produced by *V. anguillarum* and may lead to ulcers and bloody lesions on the body.

Pathogenicity: Variable. *Aeromonas liquifaciens* is a facultative pathogen and its occurrence as a disease organism is closely associated with poor water quality and stress.

Mortalities may vary in intensity and epizootics may have a slow course or be very rapid with little outward manifestation of disease.

These bacteria have been isolated from the wild and in eels held at eel-processing plants. However, they do not appear in an obviously pathogenic role in eel farms in New Zealand. Laboratory diagnosis is necessary for identification.

Treatment: Infections may be controlled by the application of chloromycetin (chloramphenicol) or oxytetracycline at 50 to 75 mg per kilogram of eels per day for 10 days or until 3 days after the last death.

Group: Phycomycetes, Saprolegniaceae.

Name: *Saprolegnia* sp. (fungus).

Signs: Fungal infections are easily recognised by the presence of patchy, fluffy, cottonwool-like areas standing out from the surface of the fish (Fig. 5). They may appear very quickly and may occur all over the fish or be confined to one area, especially the tail. Slight fungal infections may be confused with the white flaky areas on the skin and fins of eels having columnaris disease.

Pathogenicity: *Saprolegnia* sp. and other aquatic fungi are usually opportunist saprophytes, as they appear as secondary or tertiary infections on eels debilitated by previous infections. Within this context they may be pathogenic, as they are the final overwhelming infection that kills the fish. However, they are almost invariably non-pathogenic to healthy eels.

The cottonwool-like areas on the surface of the eel are small aerial hyphae extending from hyphae that penetrate the eel's tissues. When mature these hyphae bear club-shaped sporangia containing large numbers of dispersive, infective,

Fig. 4: Haemorrhagic septicaemia. Distension and reddening of the belly of an eel experimentally infected with *Aeromonas liquifaciens*.

Fig. 5: Fungus. A localised fungal infection on the tail of an eel.

flagellated zoospores. They may come in contact with plant matter or organic detritus and grow or they may infect other fish. *Saprolegnia* is very common in most natural water systems.

Treatment: Because fungal infections usually occur on emaciated or debilitated fish after initial bacterial or parasitic infections or damage, they are best prevented by treatment of the initiating mechanism. Thus, if the general health of the eels can be maintained, fungus is unlikely to be a major problem.

If fungal infections are considerable, they can be reduced by removing organic detritus from the tanks and washing tank walls and equipment in formalin (5 ml per litre), copper sulphate (500 mg per litre), or malachite green (0.15 mg per litre). Care should be taken that these solutions do not come into prolonged contact with live fish and that they are disposed of safely. These methods are not as effective as reducing fungal infections by treatment of primary and secondary infections and the maintenance of good hygiene.

Parasitic Infections

Group: Protozoa, Ciliata.

Name: *Ichthyophthirius multifiliis* (white spot, "ich").

Signs: The presence of small white bodies (less than 1 mm in diameter) on or in the skin, fins, and gills of the eel or in the water. The gills should be examined thoroughly, as white spot may be superficially confused with patches of columnaris disease or small cysts of *Myxidium* sp. The fish may rub themselves against rough or protruding objects in the tank and may cease feeding.

Pathogenicity: Heavy infections may cause debility and emaciation and high mortalities, especially among young eels. The heavier the infection and the smaller the fish, the greater is the pathogenicity of this parasite.

Adult *I. multifiliis* occur in cysts on the skin and gills of fish, where they feed and grow. They rotate rapidly in the cysts and it is thought that they feed on particles of host tissues detached by these rotational movements and on the tissue fluids of the host. Growth is directly related to water temperature. For example, maturation of one of the stages (trophozoites) occurs within 3 to 4 days at temperatures of 21 to 24°C, 2 weeks at 16°C, and more than 5 weeks at 10°C. Growth is completed within 10 to 14 days provided the temperature is above 22°C, but it takes longer at lower temperatures.

After growth and maturation are completed the adult ruptures the cyst and falls to the bottom of the tank. Here it surrounds itself with a gelatinous capsule and undergoes several divisions, after which the capsule ruptures and releases 200 to 1,000 young ciliated, pear-shaped individuals (tomites) that are the infective stage. They must reinfect a fish within 48 hours or they die. On infection they burrow into the epidermis or gills and grow to maturity. A mature individual may be readily identified by the large horseshoe-shaped macronucleus.

This parasite is very common and causes problems to fish culturists and hobbyists throughout the world. In New Zealand it occurs in natural water systems and is very common on native fishes, especially during summer. Because of this it is likely to keep reinfecting eel farms taking water directly from natural systems, and in this situation eradication may not be feasible. However, it is advisable to control the infection; otherwise high mortalities may be expected.

Treatment: Despite the world-wide distribution of this parasite, and the many studies of its control, there is still no completely suitable treatment. Such studies have concentrated on chemical eradication or

dispersal of the free-living stages, as the stages within the hypodermis or gills are exceptionally difficult to eradicate.

The choice of control method depends on water temperature, hardness, and pH and the economics and feasibility of long- and short-term baths. Of the many treatments used, the following are the most effective.

"Chloramine-T." Dosage varies with pH and water hardness from 2.5 mg per litre (soft water, pH 6.0) to 20 mg per litre (hard water, pH 8.0); 1 mg per litre equals 1 part per million (1 ppm). This method is therefore effective only in conditions where water hardness and pH do not fluctuate. Though it has given very good results, care should be taken in its application, as it produces free chlorine in the water. Most fish, including eels, have a low tolerance to chlorine, and chlorine poisoning can be suspected if fish show trembling movements, paling or discolouration of the skin, and sunken eye sockets. Because of the risk of poisoning, this treatment is not strongly recommended, and if it is chosen, a trial should first be made on a small sample of fish.

Methylene blue. Long-term bathing in methylene blue (5 mg per litre) is a fairly effective method of controlling white spot. Its advantages are low toxicity and low cost, and it is particularly effective if treatment is given as soon as the infection is noticed. However, it does have the disadvantages of being inactivated by organic detritus in the water; it adversely affects the condition of the fish, and some strains of *I. multifiliis* may be partially resistant to it.

Quinine hydrochloride. Bathing in quinine hydrochloride (10 mg per litre) has many of the advantages and disadvantages of methylene blue bathing. Though it may control white spot successfully, it is more toxic than methylene blue and therefore overdosing is dangerous; it also has to be applied as a bath for at least 24 days, and fish are in poor condition at the end of this period.

Formalin. Bathing fish in concentrations of 100 to 250 ppm of formalin has been reported, but these dosing rates are near the upper tolerance levels for most fish and are not recommended. In New Zealand long-term bathing in 30 to 40 ppm has been partially successful, but may affect the feeding and condition of young eels. The advantages of formalin are that it is cheap and readily available, and it may be very effective if it is used in the very early stages of the infection. The disadvantages are that it will kill algae, and in slow circulation ponds this may cause oxygen depletion; at temperatures below 18°C it affects the mucus on the surface of the fish.

Water flow. Reinfection may be suppressed by increasing water flow through tanks, which disperses the infective stages of white spot before they reinfect fish. Though this may give some control, eels may swim

more actively to maintain their positions; this will alter energy conversion rates and therefore decrease condition factors or growth rates.

Temperature. Changing water temperature by raising or lowering it has been used to control *I. multifiliis*, but this method is not usually feasible in culture. Raising and lowering the temperature should be done gradually to reduce stress on the eels. At lower temperatures the parasite's development is inhibited, but at warmer temperatures it is accelerated and therefore the duration of other methods of treatment can be reduced.

"Neguvon" and copper sulphate. Overseas workers have successfully treated white spot infections with "Neguvon" (0.3 to 1 ppm) and copper sulphate (0.8 ppm) given in combination as a bath. It is recommended that this treatment is given at 0.3 ppm of "Neguvon" and 0.8 ppm of copper sulphate for up to 4 days if necessary. Feeding should be discontinued during bathing, and care should be taken in the use of these chemicals, as "Neguvon" is poisonous to humans, and excess copper sulphate is toxic to fish.

"Furanace". The authors have no experience in the use of "Furanace" as long-term (0.05 to 0.2 mg per litre for 7 days) and short-term (1 to 2 mg per litre for 5 to 10 minutes) baths to control white spot, but clinical trials indicate that this nitrofuran compound may control the infection at low dosage levels. However, because white spot is likely to be a recurrent problem, "Furanace" baths may be too expensive for routine treatment. If other infections susceptible to "Furanace" are affecting the eels at the same time as white spot (for example, bacterial and fungal infections), "Furanace" baths may be of great benefit to the eels, and in these circumstances are highly recommended.

From the variety of treatments mentioned above, it is apparent that none is entirely suitable, but for routine white spot control methylene blue and formalin baths are recommended. Both are likely to affect the condition of the eels deleteriously and therefore they should be used intermittently and preferably should be alternated. "Neguvon"-copper sulphate therapy is also recommended, but care should be exercised in its application. Treatment is likely to be most effective if it is applied **as soon as the infection is detected.** A necessary part of the control of white spot should be the development of procedures and eel farm design to minimise the risk of introduction of the protozoan.

In multiple infections with bacteria, fungi, and white spot "Furanace" baths are recommended, the method of bathing depending on the feasibility of long- or short-term baths.

Fig. 6: *Myxidium*. A young elver (8 cm) dissected to expose cysts containing *Myxidium* on the gills.

Group: Protozoa, Sporozoa.

Name: *Myxidium* sp.

Signs: The presence on the gills of white cysts ranging in size from just visible up to 6 mm in diameter (Figs. 6 and 7). When small these cysts are easily confused with white spot or columnaris infections. They are distinguished by the presence of very large numbers of infective spores within the cyst, but these spores can be seen only under a high-power microscope (Fig. 8). In heavy infections the eels may show signs of

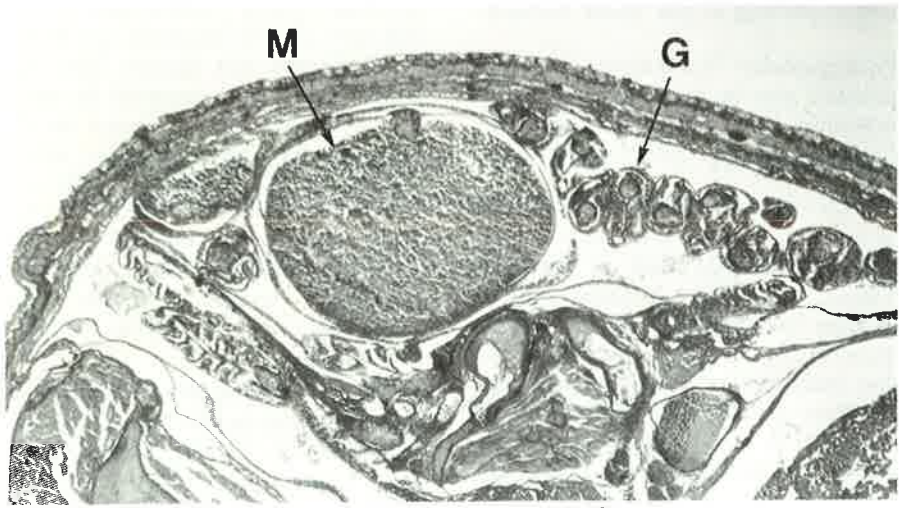

Fig. 7: *Myxidium*. A transverse section through the gill (G) region showing a cyst (M) containing spores of *Myxidium*.

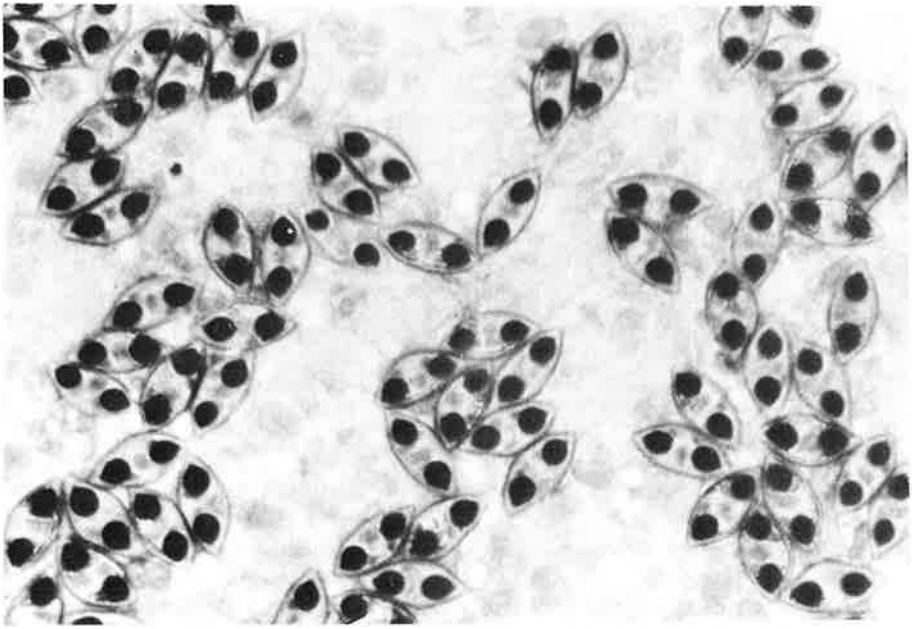

Fig. 8: *Myxidium* spores. Each spore is 7 to 10 micrometres long.

respiratory distress, swimming slowly and mouthing at the water surface.

Pathogenicity: Not known, but this parasite may be pathogenic in heavy infections in the wild and is probably pathogenic under culture conditions.

Myxidium sp. occurs in about 20 percent of long- and short-finned eels in the wild and is common throughout New Zealand. Field studies indicate that the infections may be acquired at an early age, but the incidence of infection does not increase greatly after the eels have reached 2 to 3 years old. This parasite is specific to eels and is not found on any other fish in the wild.

A cyst may destroy most of the gill filament before the spores inside become fully developed and infective. At this stage the cyst bursts and releases the spores into the water. These are ingested by more eels and these spores hatch in the intestine into an amoebula, which penetrates the intestinal wall and enters a wandering phase in the body. Once it has reached its final site and undergone many complex divisional stages, spores are produced and the cycle is thus completed.

The relationship between temperature and development is not known, but infection to the stage before spore formation takes 3 to 4 weeks at a temperature of 20 to 22°C. The eel is seriously affected by the bursting

of the cysts on the gills, which may result in considerable gill damage and eventual asphyxiation in unfavourable conditions.

Treatment: Once a sporozoan infection has been introduced into a culture establishment, it is very difficult to eradicate. The vegetative stages of the life cycle that occur within the fish are often in intimate contact with the host's tissues; therefore it is most difficult to destroy them without simultaneously damaging the host fish. The spores are usually highly resistant to conventional methods of treatment. Research on the spores of *Myxosoma cerebralis*, the sporozoan that causes whirling disease, has shown that they may become more infective with age, may survive freezing to -20°C for at least 18 days, may survive heating up to 60°C for up to 10 minutes, are not affected by low concentrations of a variety of chemicals, and may survive up to 10 years on the bottom of ponds.

If a *Myxidium* infection is detected, infected eels must be isolated as fast as possible. If very few are infected and it is economically feasible, the infected eels should be destroyed and their tank subjected to alternating drying-out and steam-cleaning periods. This work should be done thoroughly before restocking the tank with uninfected eels. After restocking, the tank should be kept isolated and the eels examined closely for signs of recurrent infection before the tank is taken out of isolation. If infection recurs, further methods of decontamination, such as sodium hypochlorite scrubbing, may be used.

If an infection occurs throughout the eel farm, the degree of infection must be minimised by rigorous attention to hygiene and restriction of the movements of infected eels. Increasing the water flow rates through the tank may keep the intensity of infection down, as the increased flow will disperse infective spores more rapidly and so reduce reinfection. In this way the infection may be controlled at sub-lethal levels. If fish attain a size suitable for export, they should be processed to remove the whole gill region and should be deep frozen to reduce the risk of exporting viable spores overseas.

If live eels are to be exported, the importing agency should be made aware of the infections before the eels are exported.

Group: Protozoa, Sporozoa.

Name: *Myxobolus* sp.

Signs: This parasite is closely related and in many ways similar to *Myxidium*. The spores are different in shape (Fig. 9) and occur in white blister-like cysts up to 8 mm in diameter on the skin of eels (Fig 10). These cysts burst to leave open pits over the surface of the eel that only partially heal. Small cysts containing *Myxobolus* spores have also been found in the gills, but the significance of this is not known.

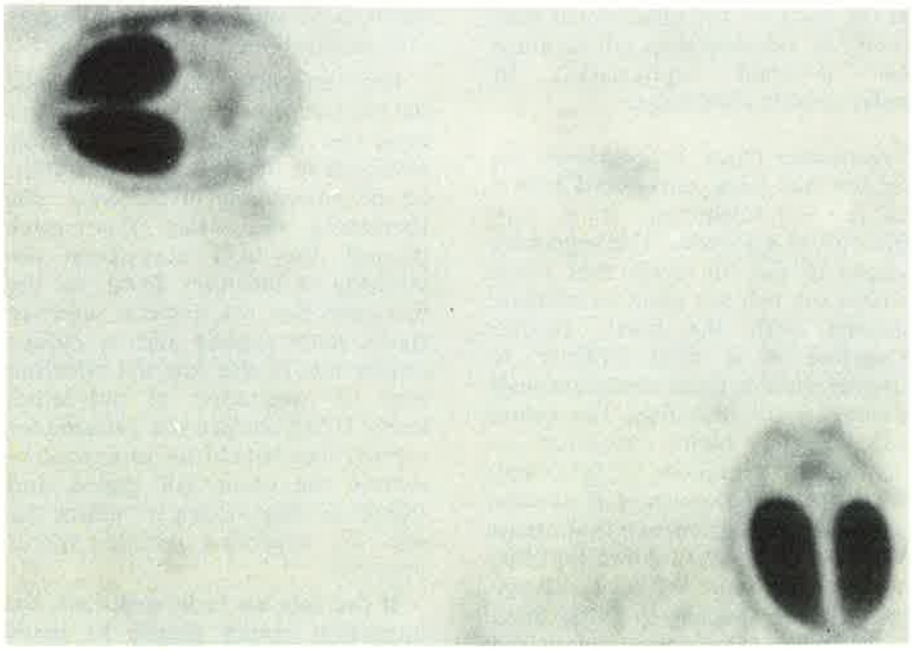

Fig. 9: *Myxobolus* spores. Each spore is 7 to 8 micrometres long.

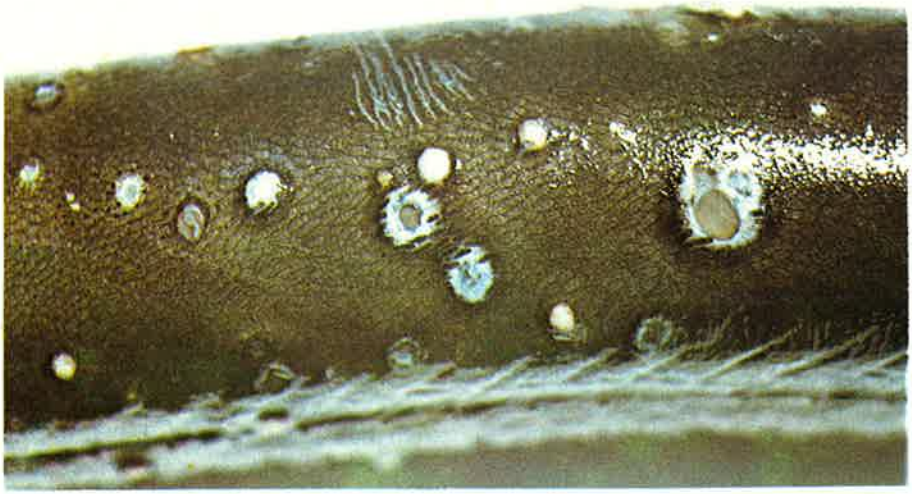

Fig. 10: *Myxobolus* cysts (left) and pits caused by burst cysts (right) on an eel from the wild.

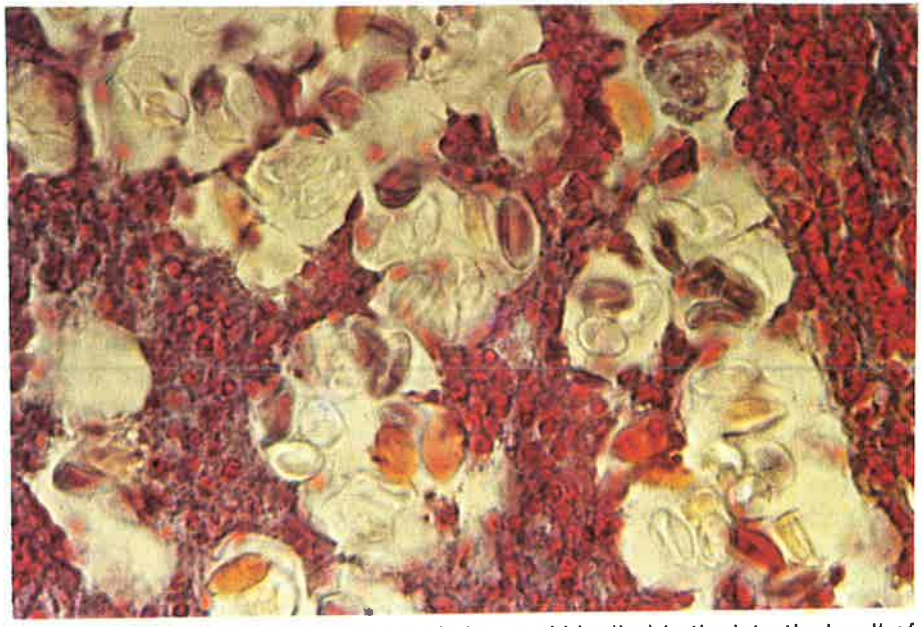

Fig. 11: *Eimeria* sporocysts (yellow and clear ovoid bodies) in the intestinal wall of an eel.

Pathogenicity: Not known. Probably non-pathogenic, though the cysts and pits formed by the parasite may cause debility and may affect the marketability of the eel. The open pits may open up pathways for infection by bacterial pathogens.

Treatment: The life cycle of this parasite is probably similar to that of *Myxidium*, except that the site of spore formation is the skin instead of the gills. *Myxobolus* is much less common than *Myxidium* in eels in the wild, but it has been found on torrent fish (*Cheimarrichthys forsteri*). A preliminary survey of wild eel populations showed that only 0.6 percent of eels had *Myxobolus* infections. Despite this the altered conditions of culture may favour the parasite considerably, and all aspects of treatment and control for *Myxidium* apply equally to this parasite.

Group: Protozoa, Sporozoa.

Name: *Eimeria* sp. (piscine coccidiosis)

Signs: Externally, the only signs may be emaciation, and in young eels the considerably enlarged gall bladder may be visible through the body wall. Internally, the gall bladder may be almost the same volume as the liver, and one or more

blister-like cysts are present on the intestinal wall. When the cysts burst small spherical bodies containing four ovoid sporocysts are visible (Fig. 11), and each sporocyst contains two sporozoites, which are the infective stage.

Pathogenicity: Not known. Probably very pathogenic in heavy infections; impairs intestinal function, causing emaciation, debility, and death.

The authors have not found this parasite in natural systems, but its appearance in an eel farm after eels were introduced from the wild indicates that it probably occurs at a low level in natural systems.

Though *Eimeria* is also a sporozoan, it is not closely related to *Myxidium* and *Myxobolus*, and it has a slightly different life history. On infection the sporozoite superficially penetrates a host intestinal cell and goes through several cycles of asexual reproduction, which results in a large number of infective individuals. Eventually some individuals undergo sexual reproduction, which produces sporocysts that are passed out, and the sporozoites infect further hosts.

Treatment: Coccidiosis of domestic birds and mammals has been successfully treated with the nitrofurans—nitrofurazone and furazolidone. Though it has not been tested against piscine coccidiosis, furazolidone added to the food at 25 to 50 mg per kilogram of eels per day for 10 to 15 days should be an effective control. "Furanace", also a nitrofuran, is likely to be effective against *Eimeria*, and if it is given at 2 to 4 mg per kilogram of fish per day for 3 to 5 days with the food, it may control the infection.

Dietary Imbalance

There is a lack of expertise in fish dietetics in New Zealand. Many conditions caused by dietary imbalances may be confused with disease signs (for example, reddening of the fins in riboflavin-deficient eels). As this subject cannot be adequately covered here, it is recommended that the paper "Qualitative Requirements of Young Eels *Anguilla japonica* for Water-soluble Vitamins and their Deficiency Symptoms", by S. Arai, T. Nose, and Y. Hashimoto, which appeared on pages 69 to 88 of volume 22 (1972) of the *Bulletin of the Freshwater Fisheries Research Laboratory, Tokyo*, be obtained through public library interloans and consulted.

Implementation of Treatment

The treatment chosen in any particular disease situation depends on the type of infection, the quality and temperature of the water, the age of the fish, the stage of the infection, the degree of debility, the design of the culture establishment, and the availability and cost of chemotherapeutic agents. Consequently it is difficult to generalise, but a few guidelines can be given.

Method of Treatment

In many cases treatment can be implemented in one way (for example, baths—quinine hydrochloride) or another (for example, in food—furazolidone), but some compounds (for example, "Furanace") may be applied in either way. Giving the drug in food has the advantage that smaller quantities of it are usually needed and it will act systemically. However, this method has a disadvantage, because one of the first signs of sickness in a fish is that it goes off feeding and therefore the sickest fish—those that need treatment most—are the least likely to receive it. Moreover, different eels will have differential rates of feeding, and in farms with a considerable range in eel size a feeding hierarchy may exist, with the smallest, weakest eels feeding less. Thus it is difficult to ensure that each eel receives an adequate quantity of the drug. Nitrofurans should be added to moist diets containing liver or animal tissues immediately before feeding, as they may rapidly decompose in such diets.

Bathing usually requires much larger quantities of the chemical or drug, and, if it is long term, it may be expensive. However, all fish receive equal treatment, even the most debilitated, and therefore bathing is more applicable to a disease situation than feeding.

When fish are being treated, or even in daily care, factors stressing them must be kept to a minimum. Many infections are aggravated by stress and thus a stressed situation such as intensive culture gives rise to favourable conditions for disease. Increasing stress further by excessive handling, damage, or exciting the fish only serves to increase the likelihood of disease. In extreme stress situations, such as transport of fish in plastic bags, low dosages of antibiotics may be added to the water as a prophylactic measure. Chloramphenicol, oxytetracycline, chlortetracycline, or a mixture of penicillin and streptomycin are suggested. It is inadvisable to add constant low levels of antibiotics to food, as this may encourage drug resistance in some strains of pathogenic bacteria.

Water Quality and Temperature

Eels maintained in poor-quality water are physiologically stressed and at a disadvantage even when a