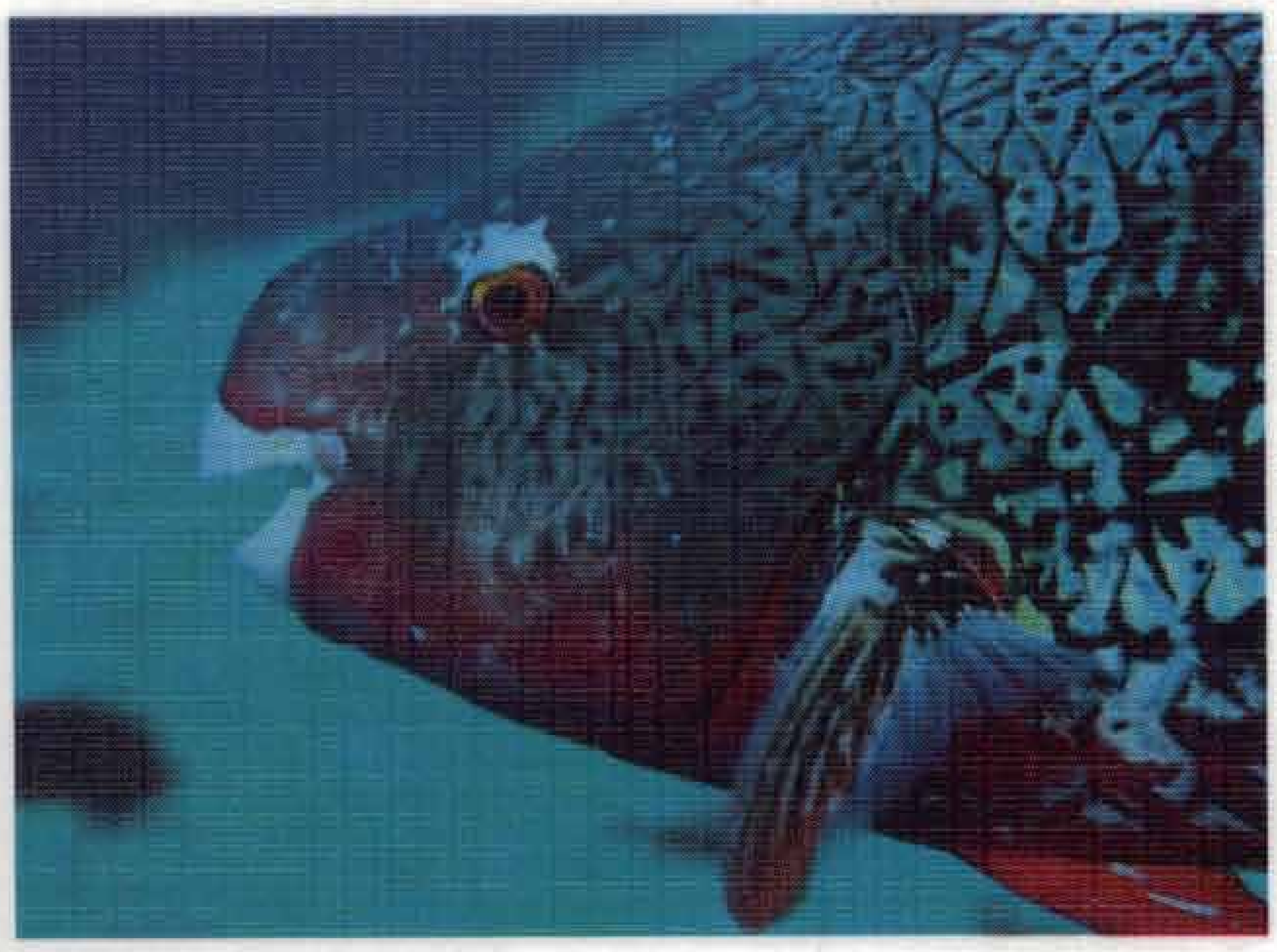
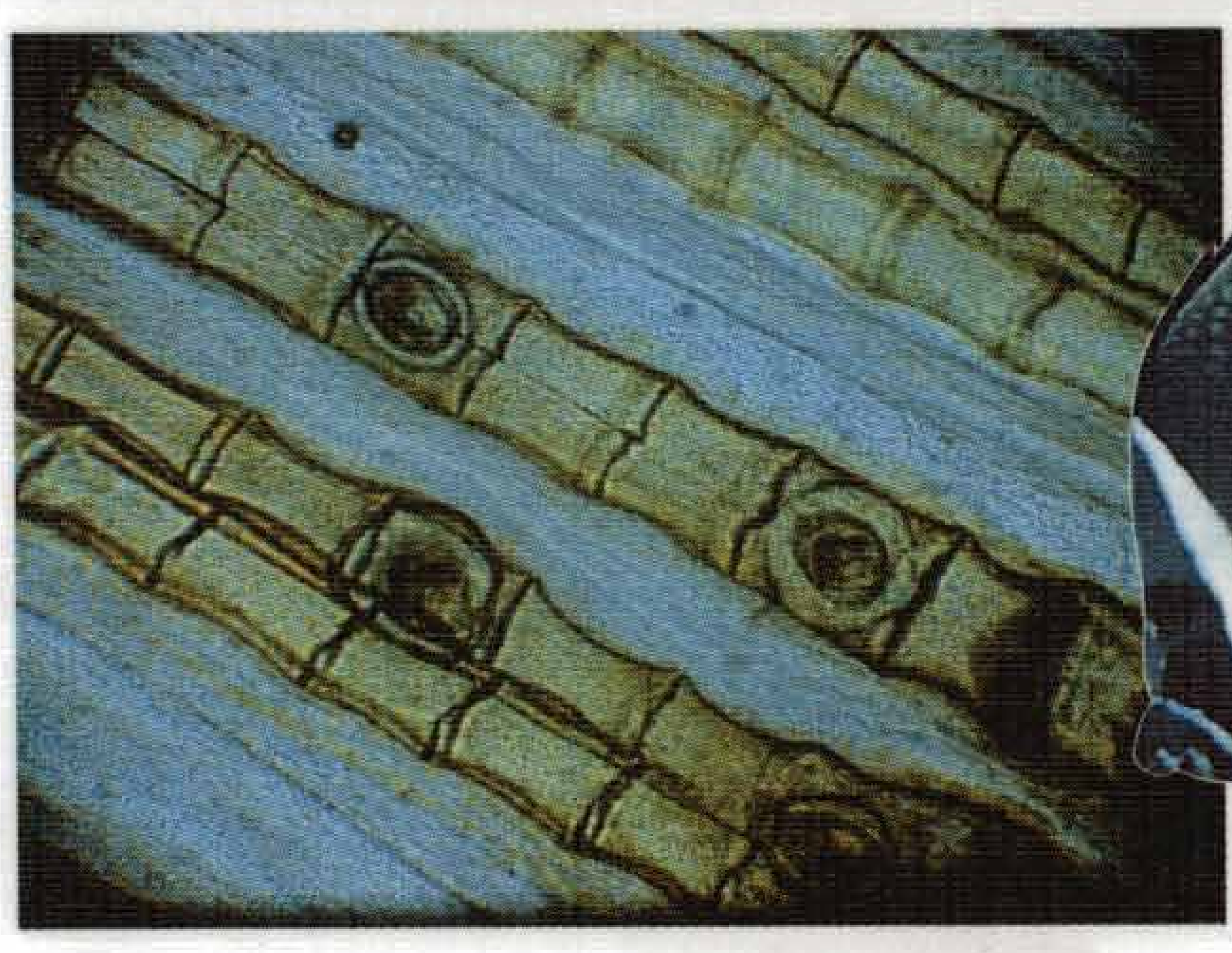
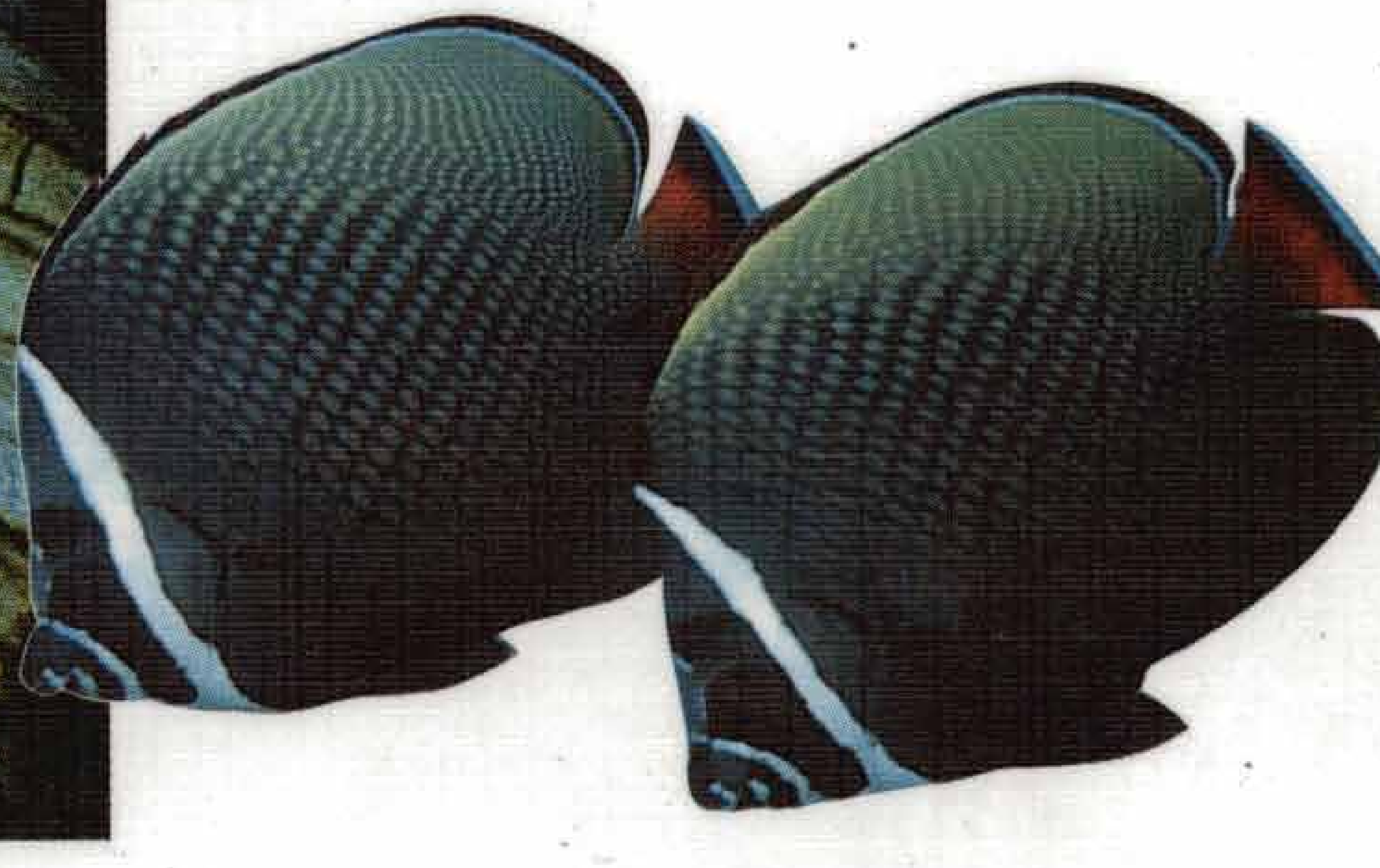
GERALD
BASSLEER

Diseases in marine aquarium fish

Causes - Symptoms - Treatment







BASSLEER biofish

Gerald Bassleer

Diseases in marine aquarium fish

Causes – Development – Symptoms – Treatment

The cover figure shows a *Genicanthus melanospilus* with a *Lernaeascus sp.* parasite (upper left), a Parrotfish (upper right), a microscopic exposure of *encapsulated digenetic Trematodes in fin rays* (lower left), and two *Chaetodon collare* (lower right).

CIP Title

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Preface

As a fish pathobiologist and Director of a wholesale company of tropical fish, I see about 1 million fish a year. This means that like other people dealing with living animals, we are constantly confronted with quality problems.
When fish are caught and transported in closely packed spaces, they exhibit increasing signs of weakness and therefore decreased immunity to disease.
I strongly hope that my knowledge and experience as presented here will help to make quality control more than just a meaningless word in our particular business. Moreover, retailers should make a point of gaining a higher level of the practical knowledge needed to sell fish.
This book is based on experience I have gained while importing and selling tropical fish as well as in training programs, and in countless contacts with fish enthusiasts, fish breeders and merchants.
In this new edition we made some minor changes, adaptations and additional text.
I hope that the pictures and accompanying text will help all marine fish enthusiasts to enjoy their hobby even more. Good luck!

Gerald Bassleer
Westmeerbeek, Belgium 2004

Acknowledgments

I owe special thanks to William Selby, owner of O'Hare Tropical Imports Inc., Franklin Park, Illinois, USA, for his understanding and financial support of scientific research on diseases in marine fish during 1981-1985.
I would like to express my appreciation to Roger Klocek, curator of J.G. Shedd Aquaria (Chicago), for his constructive criticism and interesting suggestions.
And finally, my thanks go to all aquarium hobbyists, dealers and personal friends for their contributions.

Introduction

Most marine fish, 99.99 %, in fact, come from stable ocean environments which, with their very high concentration of dissolved oxygen, constant pH, low CO_2 content and lack of ammonia or nitrite, offer the ideal living environment.
When fish are placed into a closed system such as an aquarium, the water quality, nutrition, light and temperature conditions are very different from their natural habitat. These conditions are all controlled by the aquarium owner, but since most aquaria are overloaded with waste products, their oxygen content tends to be too low while the CO_2 levels are too high. It is essential that certain critical parameters be measured and controlled. This does require a great deal of effort. However, if marine aquaria are not cared for properly, treating diseased fish with drugs is practically useless because poor water quality makes all drug treatment ineffective. Fish living in the sort of 'poisoned' water described above are susceptible to bacterial or certain parasitic infections. These are often secondary infections. In such cases, the quality of the water has to be improved as this is actually the primary cause of disease. On the other hand, this does not mean that marine fish cannot contract infections in healthy environments, although the risks are much lower. It should be noted that it is no easy task to set up a well-balanced marine aquarium. Indeed, setting one up requires considerably more knowledge and experience than simply maintaining one.
This book aims to be a worthwhile contribution to marine aquarium work, especially with respect to examining water quality, making diagnoses and treating diseased fish. The many color illustrations and microscope photos are intended to make it easier for people with aquaria to treat any sick fish. There is a definite lack of information about diseases in marine fish. I hope this book will fill the gap.

The author cannot be held responsible for any harm or losses caused to marine fish or invertebrates when applying methods recommended in this book.

Diseases in marine fish: what factors play a role?

External factors, such as excessively high or low pH, very high or low ion concentrations, and the presence of ammonia or nitrite cause *stress* in fish which weakens their immunity to disease. Thus, when water quality is poor, fish are more susceptible to infections. *Water salts* and *filtration* are two extremely important factors, so we will give them special attention.

1. Seawater

The simplest way to make seawater is to obtain synthetic sea salt. Good sea salt mixtures can be found on the market, although some aquarists prefer to make their own sea salt.
Seawater contains 96.4 % water and 3.5 % NaCl, MgCl, $MgSO_4$, $CaSO_4$, $CaCO_3$, $PHSO_4$, PBr, NaBr. Also dissolved in seawater are vital organic molecules - vitamins, amino acids, proteins, etc. and essential trace

Figure 1

Due to poor water quality such as too much ammonia or excessively low pH, fish can be severely damaged like this Butterflyfish *(Chaetodon unimaculatus)* with its red skin patches.

elements. Vitamins and trace elements can be purchased and should be added regularly to the seawater.
Salts should be dissolved in a separate container before being added to the aquarium water. The *density* or *salt content* should be between 1.018 and 1.025 g/ml. Chlorine should be completely removed, if possible, especially if the chlorine content in tap water is above 1 to 3 ppm. Appropriate testing materials (such as those used for swimming pools) can be purchased. When the water is allowed to stand for 24 hours with simultaneous aeration and heating, any dissolved chlorine will evaporate. Sodium thiosulfate ($Na_2S_2O_3.5H_2O$) can also be added, to chemically remove chlorine. This substance is contained in dechlorinating agents. Add 1 g of sodium thiosulfate per 10 liters of water to remove all chlorine.
Ammonia is sometimes added to the tap water. It reacts with chlorine to form ammonium chloride (NH_4Cl). To remove chlorine from the chemical compound, a double quantity of sodium thiosulfate must be added before the salt is dissolved in water. This is absolutely necessary at ammonium chloride concentrations of 2 to 3 ppm. Activated carbon filters will remove any remaining chlorine. Ammonia can also be removed with an ammonia absorber (such as zeolite). There is another, more complex method of removing ammonium chloride. This consists of adding bleach (1 ml per 4 l) and sodium thiosulfate to remove the chlorine. However, this is a rather complicated, labor-intensive method, so we recommend the first method.

2. Filtration

Biological, mechanical and chemical filtration systems are required in marine aquaria. Where central filter systems are in operation, UV radiation should be used to disinfect the water.
Residual feedstuff and dissolved waste products such as ammonia, nitrite, nitrate, proteins, amino acids, phenols must also be removed.
Mechanical filtering is used to remove large (insoluble) particles from the water. Different kinds of filter material can be used for this purpose, such as fine or coarse sand. External filters are normally used in aquaria. The efficiency of mechanical filters depends on the following three factors:

1) the speed of water flow through the filter;
2) the volume of the filter;
3) the coarseness of the filter material.

In principle, biological filters work like mechanical filters, and depending on capacity, external mechanical filters work like small biological filters. Mechanical filters provide good water circulation, and are therefore useful in maintaining sufficient concentrations of dissolved oxygen.
Chemical filtration is used to remove dissolved substances from water and usually consists of the following methods: activated carbon filtration, protein skimmer, ion exchanger or oxidation via ozonization.

– When used in combination with mechanical filter systems, *activated carbon filtration* is a good and frequently used method, especially in external filters. However, it is not effective in removing ammonia, nitrite or nitrate. Another disadvantage is the fact that it also removes vital trace elements for fish and especially for invertebrates from aquarium water. As a result, activated carbon must be removed regularly or additional trace elements added. Activated carbon must also be removed when drugs are administered to the whole aquarium.

– The principle of the *protein skimmer* consists of bringing air into contact with the residual proteins in the water so that these form a layer on the surface and can be removed. For this purpose, air is allowed to bubble into the water through the tubing system. The protein molecules adhere to the surface of air bubbles enclosing them with a thin layer. The air bubbles then burst on the water surface and the protein enclosure changes into foam. In addition to proteins, detergents, amino acids, fatty acids, and dyes are removed from the aquarium water. Unfortunately, essential vitamins and trace elements can also be removed.

– *Ion exchange* is primarily used to soften water. Consequently, ion exchangers are of no use in marine aquaria.

– *Ozonization* is a method by which ozone (O_3) is bubbled through the water causing organic substances, bacterial and parasites to become oxidized (burnt). This is a very delicate and thus dangerous method since it causes nitrate to be converted back to ammonia, resulting in the risk of poisoning. If too much ozone is added, gills may also become 'burnt'. As a result, we do not recommend that amateur aquarists use this method.

– Usually, *UV sterilization* is used in closed filter systems where several aquaria are connected to the same filter or water circulation system. In this method, water flows through tubes surrounded by UV lamps. All bacteria and parasites located up to 2 cm from the lamps are killed. However, these lamps are only effective when they can deliver at least 25,000 $\mu Ws/cm^2$.
This method can be used to effectively prevent diseases from spreading from one aquarium to another, and so is recommended for closed systems. During drug treatment, UV lamps must be turned off to avoid decomposing the medicine. However, to date little is known about this. Some experts warn of possible hazards associated with copper sulfate treatment. We have not had any negative experience in this regard. With some diseases, UV sterilization should be continued to prevent the spread of bacteria, viruses, fungi or unicellular parasites (such as juvenile stages of *Cryptocaryon, Oodinium* and so on) or at least to reduce their spread. After one year of operation, the lamps should be inspected to determine whether they are still fully effective.

– *Biological filtration* is a critically important factor in aquaria. Toxic waste products (such as ammonia) are converted into less toxic substances by organisms such as nitrifying bacteria *Nitrosomonas* and *Nitrobacter sp.* Residual food, dead fish or invertebrates are decomposed by aerobic bacteria. Proteins are converted to ammonia (NH_3). Most ammonia comes from the excreta of fish (via gills and anus) and invertebrates. Large quantities of dissolved ammonia are found in aquaria with high pH, such as marine aquaria (pH: 7.9 to 8.4). The higher the pH of the water, i.e. the more alkaline, and the greater the quantity of OH^-, the more NH_3 it contains. The lower the pH of the water the more acid and the greater the quantity of H^+, the less ammonia there is and the more non-toxic ammonium (NH_4^+) there is. Thus, the pH level is critical in ammonia poisoning in marine aquaria. Problems can occur with marine fish and invertebrates from as little as 0.15 mg of ammonia/liter. *Nitrosomonas* bacteria consume ammonia and convert it into nitrite (NO_2), which is toxic for marine fish in concentrations of 0.1 mg/l. *Nitrobacter* bacteria consume nitrite, converting it to nitrate (NO_3), which is the final product of biological filtering. This nitrate is removed from seawater in three ways: absorption by algae, water replacement and anaerobic filtration. If it is not removed, the nitrate builds up to the extent that all living organisms in the aquarium are endangered. Fish and invertebrates may suffer damage at concentrations as low as 50 to 100 mg/l.

How do we initiate biological filtration?

Either by placing filters on the aquarium floor or by installing an external filter which functions as a biological filter. It is essential that a coarse surface be created with the filter substrate so that as many bacteria as possible can settle on it. Biological filtration can take place to a small degree in aquaria without a filter owing to the presence of *Nitrosomonas* and *Nitrobacter* bacteria on the floor, stones, walls, etc.

The greater the number of nitrifying bacteria, the more waste product (ammonia and nitrite) can be processed. The filter substrate can be made from coral sand or - in the case of external filters - by filtering the water via plates, grids, ceramics or small plastic balls or tubes. Be certain that the coral sand layer covering the filter on the bottom is not thicker than 5 cm, as aerobic and nitrifying bacteria nest in the upper 2 to 3 cm only. If the coral sand layer is too thick, an anaerobic environment may develop in the filter bed. This is recognizable as black spots from which toxic gases produced by anaerobic bacteria periodically escape. Moreover, water must flow sufficiently quickly through the biological filter to guarantee optimum filtration.

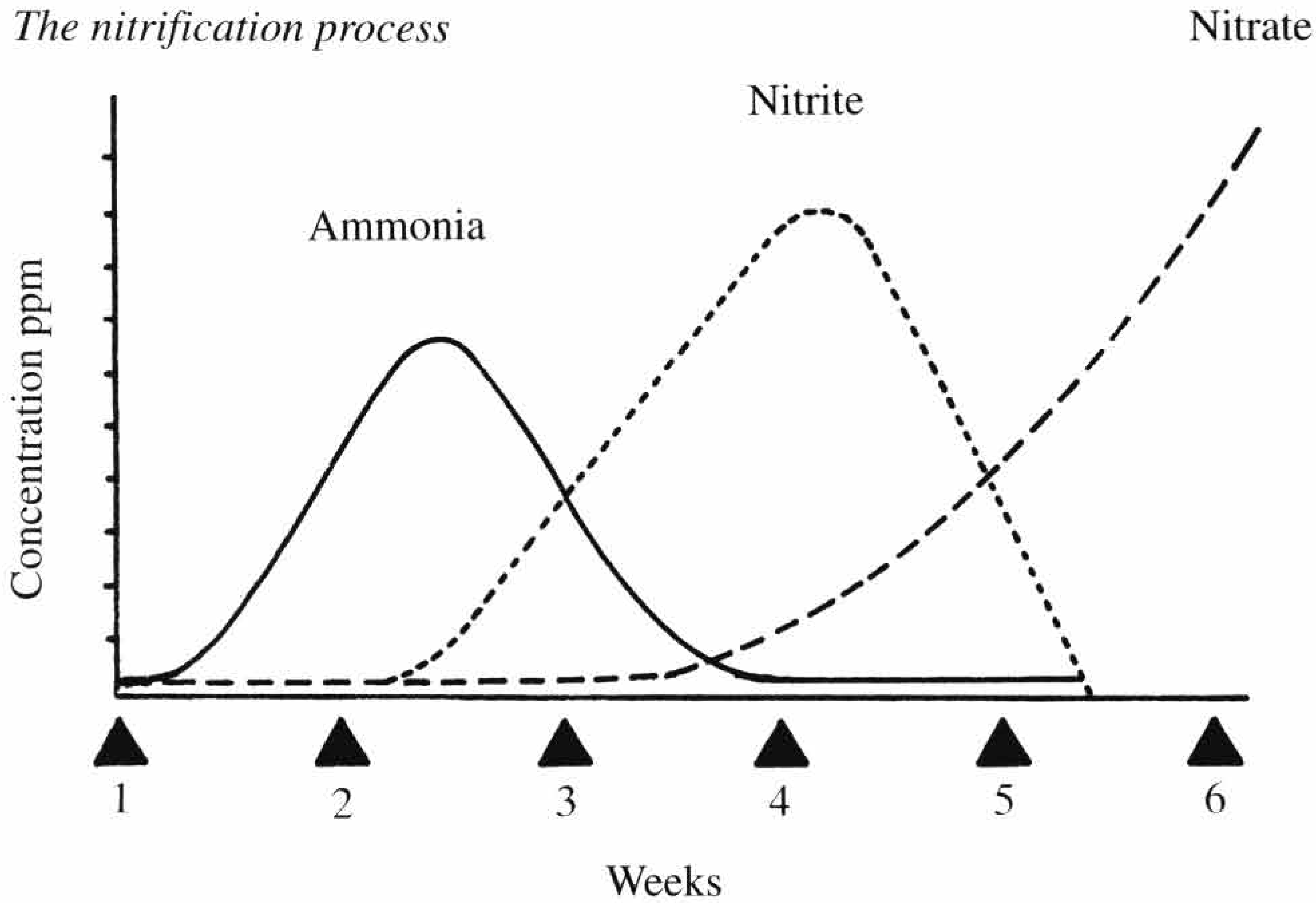
Time is important when installing a biological filter. Sufficient quantities of all bacteria are available only after three to eight weeks. If fish are introduced into the aquarium too soon they may all die due to lack of nitrifying bacteria or from excessive waste product which cannot be decomposed quickly enough. Some robust fish or invertebrates should be placed into the aquarium about one day after starting biological filtering in marine aquaria. Some Damsel Fish (e.g. *Abudefduf sp.*) and hermit crabs or anemones (e.g. *Condylactus sp.*) are very suitable for starting filtration. They produce the first quantities of ammonia on which the first *Nitrosomonas* bacteria feed. After a certain time, *Nitrosomonas* bacteria excrete nitrite on which *Nitrobacter* bacteria feed and develop. This nitrifying cycle can be accelerated by placing a culture (colony) of nitrobacteria into

the aquarium water. This can be done by transferring a handful of filter substrate from an established marine aquarium into a new aquarium. You can buy small bottles of nitrobacteria. Within 3 to 8 weeks, the concentration of, first, ammonia, and later, nitrites, will peak (*see Figure*). The peaks concentrations may occur in less time. In fact, some nitrifying cycles take place in 14 to 21 days, depending on the aquarium.
During this first phase, *water quality* should be *examined* for ammonia, nitrite and nitrate to determine whether the process is progressing as desired and whether more fish and invertebrates can be introduced into the aquarium. There are numerous test sets on the market for performing the necessary water tests.
In this first phase, one fifth of the water must be replaced every week and sufficient oxygen must be introduced through vigorous water circulation assisted by a good external filter and an oxygen pump. With the removal of excessive amounts of ammonia and nitrite and through oxygen enrichment provided by fresh water, bacteria can multiply sufficiently.

When the nitrite concentration decreases after a few weeks, more life should be added to the aquarium. Fish or invertebrates should be placed in the aquarium a few at a time over several days or weeks. Bacteria production must then be allowed to adapt gradually to the larger quantity of ammonia. If too many marine fish or invertebrates are introduced into aquaria, ammonia poisoning may result. This can kill all living organisms in the aquarium, including bacteria.
Biological filtration can also be triggered *chemically*. To achieve this, ammonium chloride (NH_4Cl) should be added to the water to feed the bacteria and cause them to multiply. Subsequently, chlorine must be removed from the water using sjodium thiosulfate ($Na_2S_2O_3.5H_2O$).
I prefer natural methods and like to start with a few fish and/or invertebrates. If necessary, additional bacteria can be added. However, a few inhabitants may be lost during the ammonia and/or nitrite peak. When this cycle is completed, and if this biological process has been allowed to run its course, we have successfully passed our critical test as marine aquarists. The final product of biological filtration is the nitrate produced by *Nitrobacter* bacteria. Algae gradually form during the first months, feeding on the slowly accumulating nitrate. Brown algae (diatoms) develop on stones and walls, followed later by green algae, provided that there is enough light. 10 to 25 % of the water should be replaced every month so that the quantity of nitrate formed can be limited (no more than 50 to 75 mg/l).
For aquaria larger than 300 liters, a filter on the inside of the aquarium is often insufficient. A second biological filter should then be installed outside the aquarium so that waste products can be removed. This also applies to algae in aquaria. An algae filter is sometimes required in the aquarium. This means that if the aquarium is home to a large number of fish, the biological filter should not become overloaded. If there are too many fish, too much waste is produced and the bacteria cannot fully decompose it. Ultimately, oxygen content may drop, resulting in increased toxicity in the aquarium and poisoning of the bacteria.

The *capacity of the aquarium* depends on a combination of the quality of filter substrate, algae, light, and mechanical and chemical filtration etc. As a result, it is extremely difficult to say how many fish can live in a certain aquarium. As an average, I would suggest one 8-10 cm fish to every 30 l of seawater. This can vary considerably from system to system and from species to species.

The nitrification process



If these factors are not taken into account, few or no green algae may develop, and instead of a pH that is too low (7.8 or below) you will have yellow-colored water and an excessive nitrate load (with small quantities of ammonium and nitrite). Under conditions such as these, fish behave abnormally and are extremely susceptible to diseases.

3. Problems and first warning signs

- If too many fish are placed in an aquarium, and if they are overfed and filtration is poor etc., excessive amounts of *toxic products* may be produced. These are given off by bacteria or released by excessive waste.
- *Black spots* in the filter on the aquarium floor suggest an anaerobic environment in which sulfur bacteria release a gas with an odor like rotten eggs (H_2S). This can be prevented if the floor sand layer is no more than 5 cm thick and if there is good filtration, a good flow through the filter substrate and a sufficient oxygen supply.
- Aquarium water *turns yellow* when phenols formed during bacterial decomposition of waste products oxidize as a yellowish substance. Protein colloids can also contribute to this yellow coloration when very large quantities of these are present in the environment.
- Sometimes when the bacteria concentration is too high, *white cloudiness* occurs. This also occurs with high levels of organic waste products and poor mechanical filtering.
- Marine aquaria may have an *unpleasant onion-like odor* caused by amines (produced from amino acids inbacterial decomposition). This occurs when aquaria are over-populated or nitrifying bacteria have been destroyed, for example, when antibacterial drugs have been administered or in the case of poisoning in the aquarium.
- With insufficient oxygen, fish may not only suffocate but *rot. Rotting processes* are associated with unpleasant odors caused by indoles and skatoles.
- Fresh coral sand provides sufficient pH buffering due to the release of Ca and Mg. However, this buffering effect weakens after a few months. If the *pH remains too low* even after water or coral sand has been replaced, adjust the pH chemically by, i.e. adding 1 part sodium carbonate (Na_2CO_3) and 6 parts sodium bicarbonate ($NaHCO_3$) to the water, whereby CO_2 is bound to $CaCO_3$ and PO_4 to $CaPO_4$ and $MgPO_4$.
  Approximately 10 g of sodium bicarbonate and 2 g of sodium carbonate in 100 liters of saltwater should be sufficient to increase the pH from 7.8 to 8.2.
- With respect to *algae*, brown algae (diatoms) are initially present but change later into green algae. Red or blue algae suggest that the environment is poor, e.g. over-production of waste products, too much ammonia, too little light etc. These undesired algae must be removed together with any waste products.
- Large quantities of *small Copepods* are often found on the bottom, corals and glass walls of some dirty, poorly maintained aquaria. These are not parasites but substrate eaters that live happily in filters in which fish byproducts collect. They disturb the biological equilibrium by reducing oxygen levels and even creating an oxygen deficit. These animals can only be eliminated by thoroughly cleaning the aquarium filter or dismantling aquaria. Drugs such as trichlorfon cannot help resolve this

problem. These small crustaceans enter aquaria with invertebrates such as live rocks, starfish, and tubeworms.[1]

4. Primary precautionary measures

To make sure that none of the problems mentioned above arise, aquaria should not be over-populated, inhabitants should not be overfed and effective filtration must be provided. Moreover, it should be remembered that it is extremely important for aquarium *water* to be *changed* regularly (*Figure 1*).

The water should be changed when nitrate levels reach 75 to 100 mg/l. It should also be changed when the pH drops below 7.8 due to excessive CO_2, nitrate, phosphates, acids, and organic waste.

In addition to changing the water, it is essential to clean the filter layer on top. This ensures that the balance of nitrifying bacteria is not disturbed. Nevertheless, excessive waste products, which can damage the whole system, are removed. The entire filter should not be dismantled, nor should the filter system be extensively cleaned, otherwise the whole biological nitrifying cycle has to be restarted.

Other factors

Light in aquaria should be as close as possible to the intensity of daylight so that optimum algae growth is possible. Thus, several hours of sunlight daily can have a positive effect on aquaria. On the other hand, over-production of algae is not desired.

Water temperature should be between 24°C and 28°C. The *salt concentration* or *density* should be between 1.018 and 1.028 g/ml. Invertebrates can tolerate higher densities (1.024 and above) much better than most tropical marine fish. Lower densities can help combat external parasites such as *Oodinium*, *Cryptocaryon* etc.

The quantity of *dissolved oxygen* in aquaria is absolutely essential for fish, lower life forms, algae and especially nitrifying bacteria. Maximum levels of dissolved oxygen in water are not achieved with air pumps which produce air bubbles, but by means of another method in which air is brought into contact with water. This is achieved primarily by turbulence or circulation of water with the help of a pump or filter (usually external filters). This 'waterfall' effect introduces an ideal quantity of dissolved oxygen into water, i.e. approximately 6 to 8 ppm.

At higher densities and/or temperatures, there is less dissolved oxygen in water. Since the oxygen concentration in tropical marine aquaria can drop

[1] See also de Graaf, F. (1973): Marine Aquarium Guide, The Pet Library.

to dangerous levels, an appropriate form of water circulation is essential. If there are leaks in external filters or if the filter water level is too low, too much air can get into the aquarium. Fish take in this gas in the form of visible gas bubbles. This phenomenon is known as *gas bubble disease* (*Figure 2*).

The *acidity* (pH) should be between 7.8 and 8.4. By releasing calcium carbonate ($CaCO_3$), the coral sand contributes to buffering and stability. If the pH drops below 7.8, the water must be replaced and excessive organic waste removed from the bottom and the filter of the aquarium. With the accumulation of nitrate, the degree of acidity decreases over time. As a result, the coral sand on the bottom and the filter material should be regularly cleaned to remove excessive waste. To increase the pH, buffers can be purchased or sodium bicarbonate and sodium carbonate can be added. If the pH is too low, fish develop white skin spots and damage to the mucosa. If the pH becomes too high (greater than 8.5) due to excessive algae formation, some of the algae should be removed.

Food is vital for living organisms to remain in good health. It is vital that fish receive the nutrients they require. *Variety* is particularly important, ensuring that fish receive vital carbohydrates, fatty acids, proteins with amino acids, vitamins, minerals etc. A lack of variety in their diet leads to fatty organs, vitamin deficiencies or other deficiency symptoms, growth disorders, deformities, blindness (vitamin A deficiency), weight loss, skin coloration or even death. There is a wide range of fish food readily available on the market, including flakes, freeze-dried products, deep-frozen or live feed animals; so a diversified diet is easily attained.
The *combination of fish species (compatibility)* in the same aquarium is just as important as nutrition. However, it is very difficult to say in advance which species will tolerate one another.

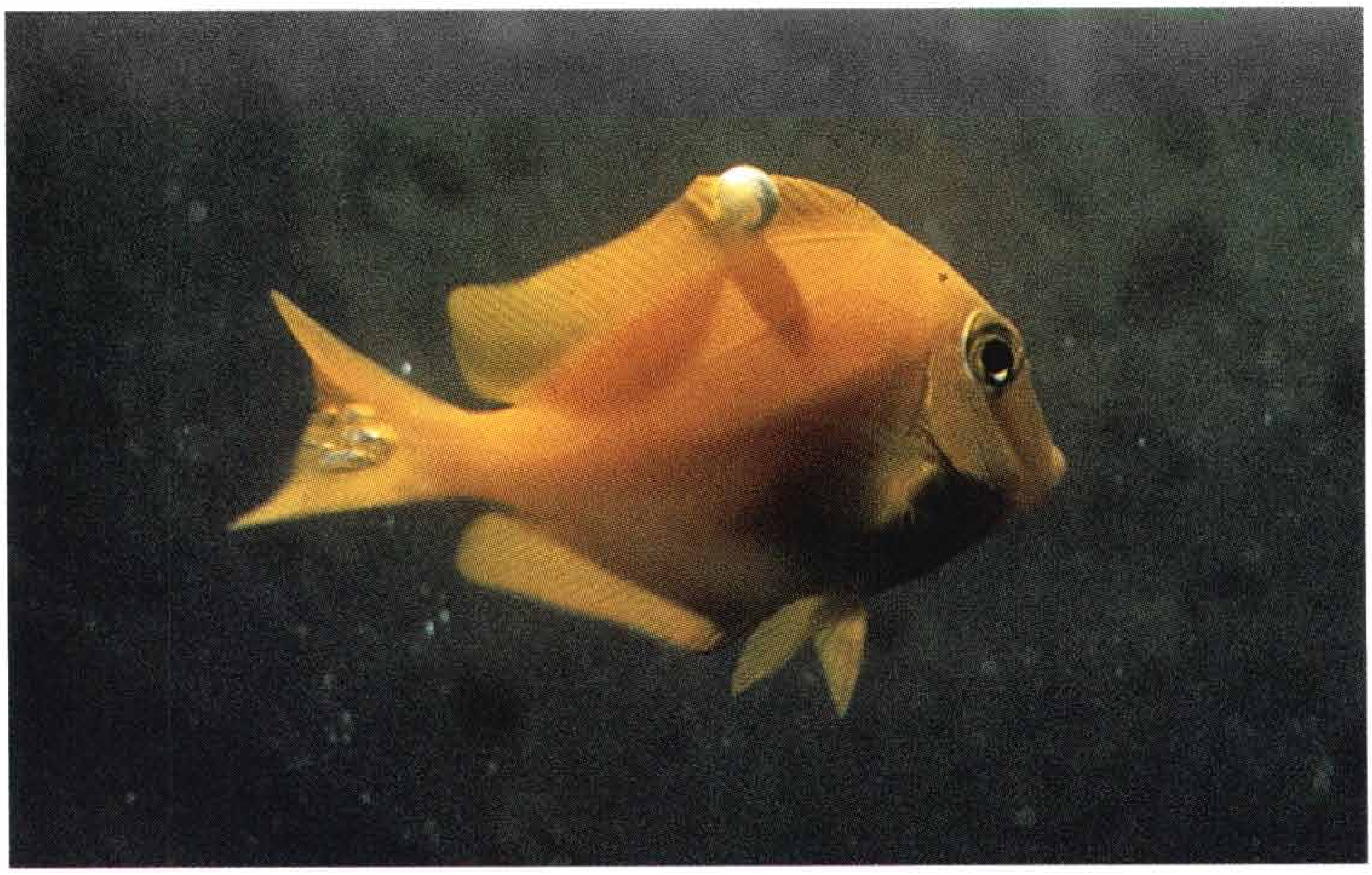


Figure 2

Gas bubbles, here on the fins of a *Acanthurus olivaceus*.
Damage is often irreversible.

Fortunately, there are some golden rules. Aquarium owners wishing to learn more about this subject should refer to the works of de Graaf (1981), Kingsford (1979) and Moe (1982), where the subject is dealt with in depth. The authors discuss the following defining factors in detail: species of fish, size, sexual maturity and activity, eating behavior, and living space with hiding places. It is obvious that large sea bass or morays should not be mixed with damsels; anemone fish couples can often be very aggressive, and two Emperorfish of the same species will more than likely attack one another. Triggerfish can also be aggressive towards other kinds of fish (*Figure 3*).

If such dominant and aggressive behavior is not taken into consideration, weaker fish may experience substantial stress, lose strength, be injured and even contract secondary diseases.

To prevent new inhabitants (fish or invertebrates) from bringing diseases into an aquarium, they should be placed into *quarantine tanks* for a period of 10 to 14 days. When buying new inhabitants for your aquarium it is important to determine whether they are in good health and will eat available food.

As a preventive measure, marine fish can be placed into a *freshwater bath* before they are allowed to enter their temporary environment. Small aquaria, buckets or other containers can be used. The freshwater must be the same temperature and have the same degree of acidity (pH) as the seawater. The water must be dechlorinated, if necessary by using sodium thiosulfate ($Na_2S_2O_3.5H_2O$) (approximately 1 g/10 l) or by aerating for 24 to 36 hours. By adding sodium bicarbonate ($NaHCO_3$) to the freshwater (1 teaspoon to 100 liters), pH values between 7.8 and 8.3 can be obtained. This freshwater bath should last for a minimum of 3 to 5 minutes so that any parasites (e.g. *Oodinium, Cryptocaryon*, skin and/or gill worms) are destroyed. Fish may suffer from shock during the first seconds. However, normally this does not last long. As long as the fish do not exhibit severe shock symptoms they may be left in the water. No more than 10 to 15 minutes are necessary.

After the fish have been placed into the quarantine tank they can be treated with antibacterial drugs (e.g. neomycin, nitrofuran) against possible bacterial infections and with malachite green, formaldehyde or copper sulfate against possible parasites.

Quarantine tanks must be suitable for different types of fish and should have hiding places, external filters and if necessary, sandy bottoms. Biological filters are not needed as long as the water is renewed and examined regularly. If the fish are in good condition after 10 to 14 days, they can be introduced to their final home after another short freshwater bath. To ensure that old and new fish adapt to one another, new fish can be kept in small containers or nets within the aquarium. No matter how many precautions you take or how well the aquarium is maintained, ammonia or nitrite poisoning is common in marine aquaria. Measures must be quickly taken to prevent the worst possible consequences.

In the case of *ammonia poisoning* fish exhibit a lack of balance. They often move wildly and uncontrollably against the walls or objects in the aquarium, which can result in injury. They tend to be extremely irritable and nervous and sometimes exhibit accelerated breathing. In such cases, the best solution is to *renew the water or move the fish*, while looking for the cause of ammonia poisoning. A similar procedure can be used in case of *nitrite poisoning*, in which the fish should be treated with methylene blue (1 mg/l). When the nitrite content is too high, the fish usually remain listless on the bottom of the aquarium while exhibiting accelerated breathing.

When the pH is too low, patches of skin, even around the eyes, will look slimy, white and cloudy. In more advanced stages, skin hemorrhaging may develop. Breathing becomes accelerated, and the fish become listless. This problem can be solved by changing the water and/or buffering of the water (with 6 parts of sodium bicarbonate and 1 part of sodium carbonate). *Insecticides* used in households, *paint* or *glue vapor* can all cause poisoning. Other 'unknown' causes of death include *metallic poisoning* from copper and iron. Some spring water or tap water contains high concentrations of metals, which are increased by regularly changing the aquarium water. As a result, when installing marine aquaria, metallic objects should not be used, especially if these will come into contact with seawater.

Figure 3

Aggressive behavior in fish can have nasty consequences for losers. Here a *Ptereleotris splendidum* with bitten-off fins.

A great deal has already been written about *cyanide poisoning*. Led by the late publisher, Don Dewey, and especially the author, Steve Robinson, Freshwater and Marine Aquarium (FAMA) Magazine has made a number of major contributions to this topic.[2] Fish poisoned by cyanide have practically no chance of survival because their digestive systems are usually attacked by the cyanide, resulting in impaired food intake and digestion. After a period during which fish lose weight, become listless, exhibit color changes and lose their appetite, they usually die. These fish may also die suddenly without exhibiting any abnormal symptoms.

Cyanide is used mainly in the Philippines and other Asian countries by divers ('fishermen') to stun fish so that large numbers of undamaged fish can be gathered from the coral reefs. Many fish are poisoned immediately after coming into contact with this anesthetic or die after a few days or weeks in aquaria. Stressful conditions during transportation and the method of catching fish described above are responsible for the increased mortality of fish imported from several Asian countries.

At the same time, this method of fishing is irreversibly destroying centuries-old coral reefs. However, the greatest tragedy is the increase in infant mortality in the Philippines. This has been attributed in part to this method of fishing since edible fish also come into contact with the cyanide used to catch ornamental fish.

In view of such worrying consequences, it is clear that urgent work needs to be done to alter fish-catching methods in the Philippines. This will only be possible if divers are not merely reprimanded but also financially supported. With fish prices being so low, impoverished fishermen in the Philippines are obliged to catch large quantities of fish in order to feed their families. The use of cyanide-filled spray bottles is seen as a harmless method for catching more fish in a shorter time.

Divers should be equipped with suitable catching equipment so that anesthetics no longer have to be used. The use of natural methods does not reduce profits, despite common arguments.

There is no doubt that new catching methods need to be legally monitored by the Philippine authorities. Fortunately, exporters, importers, retailers and aquarists are becoming increasingly aware of this problem and are protesting against the use of cyanide. It has come to my attention that a Filipino organization working with a number of divers, including Steve Robinson, has already been retraining a large number of 'fishermen' since 1984. My greatest wish is that binding legal regulations will follow to protect both man and animals.

We are happy that now (2004) a new group with support from the trade and animal welfare is organizing 'certified cyanide-free' collection. For more info see MAC (Marine Aquarium Council) or www.aquariumcouncil.org.

[2] Robinson, S. (1983-84): Collecting Tropical Marines. Freshwater and Marine Aquarium (FAMA) Magazine, Sierra Madre, CA, Vol. 6, 7-12 Vol. 7, 1 - continued.

Diseases in marine fish: symptoms and treatment

From an economic standpoint, scientific research on edible fish such as trout or salmon is considered to be more important than that on ornamental fish. So it is no surprise that more is known about diseases in edible fish than in their ornamental cousins. And in turn, more is known about diseases in tropical ornamental fish than in other types. In any case, marine fish have just as many problems with diseases. This can be attributed to the fact that 99 % of the tropical fish in domestic aquaria are caught in the wild and transported to retailers and wholesalers - a process which can take from 24 to 48 hours. Removing fish so suddenly from their natural environment exposes them to considerable *stress*, from which they may also die. In addition, marine fish surviving transportation may also have diseases, and so pass on their infections to the fish already in aquaria.
It is important to note that marine fish first have to adapt to their new environment, which in itself can cause problems. As a result of the stress to which the fish are exposed, their defense mechanism is often weakened to such an extent that they are more susceptible to diseases. This is why quarantine tanks are so important.
Genetic anomalies and geriatric problems are not discussed in this book.

1. Examination

A microscope is a vital piece of equipment for diagnosing diseases in fish.*
Skin and gill smears or fins and gill parts have to be examined in seawater on slides. In seawater, the structure of cells, bacteria and parasites remains intact, while freshwater can damage them.
Freshwater can be used to examine internal organs. As in methods used to examine freshwater fish, small samples of, for example, liver, spleen, gall bladder, intestines, kidneys, or air bladder are pressed between a slide and a coverslip and examined under the microscope. Excreta and blood can also be examined microscopically.

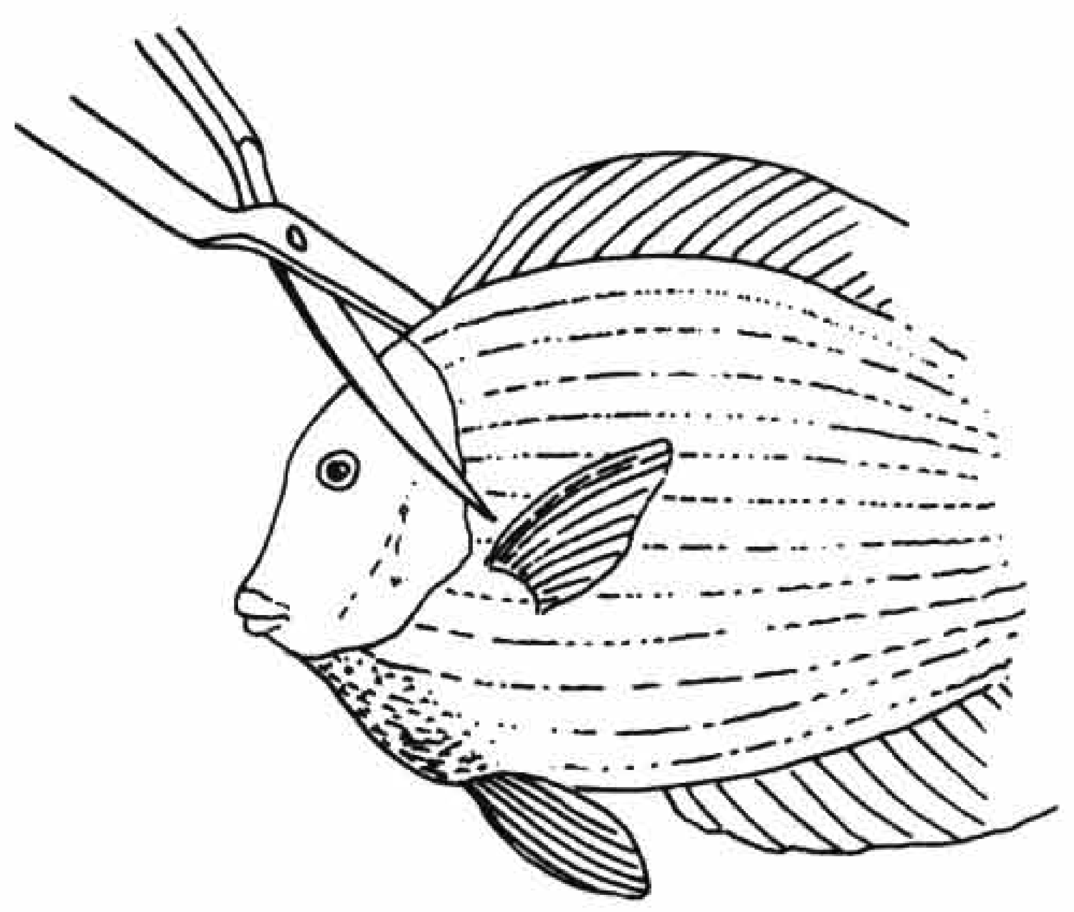
* We should strongly advice only to examine fresh fish.

A microscope is essential for making an exact diagnosis. The descriptions of individual diseases which follow underline this requirement. Many large-scale symptoms of diseases are very similar and can easily lead to mistaken choice of drug treatments, with possibly harmful consequences.

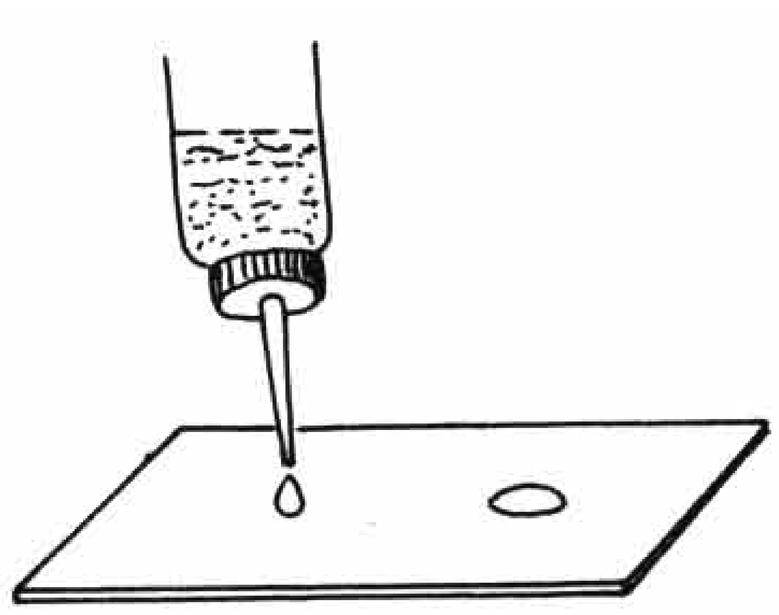
In reviewing diseases, illustrations of diseased fish in microscopic preparations provide hobbyists with a clear concept of the diseases.

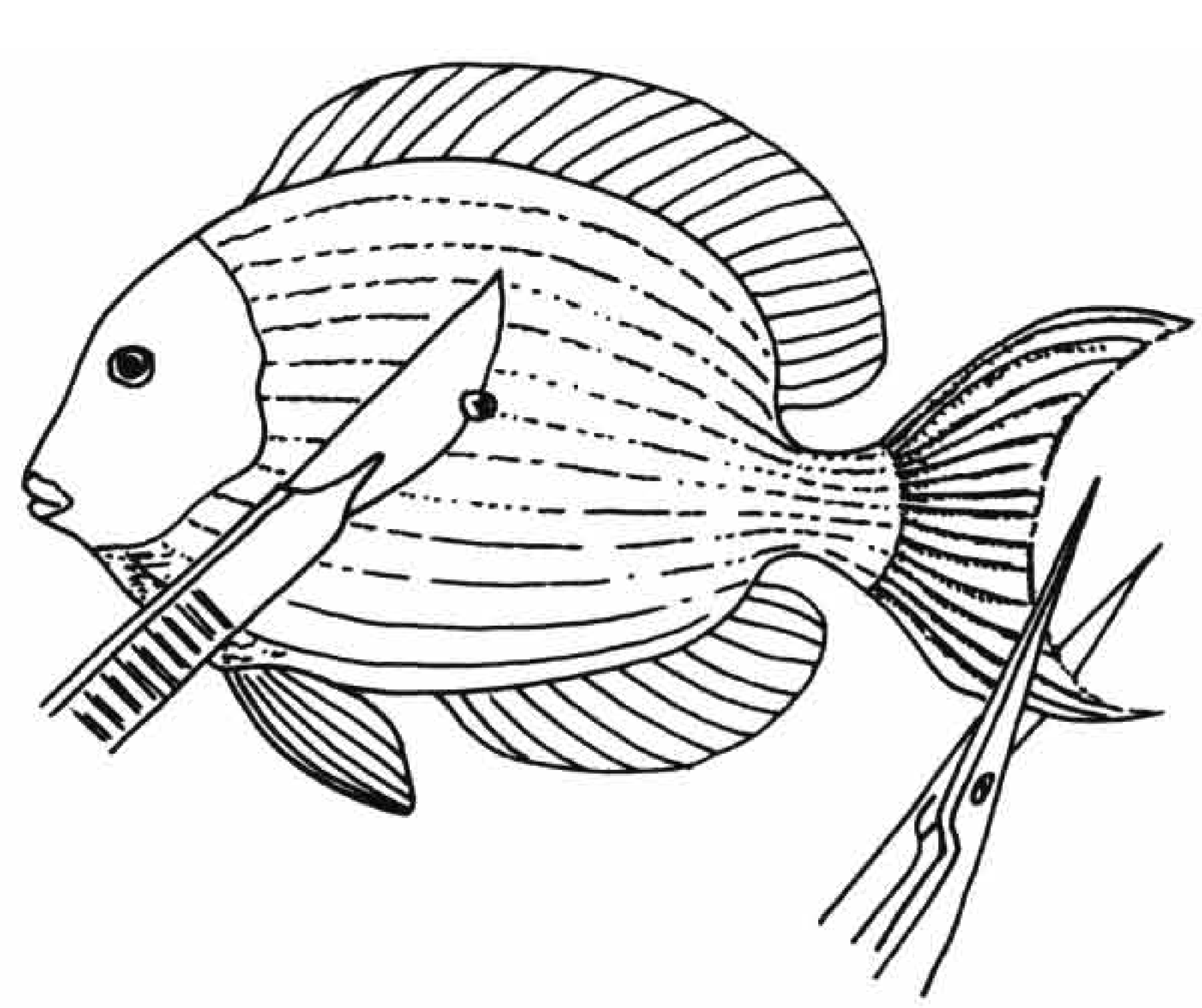
The material required to carry out examinations consists of two dissecting needles, one small and one large pair of scissors, a scalpel with replaceable blades, one sharp and one blunt pincer, as well as a small eye-dropper containing aquarium water.

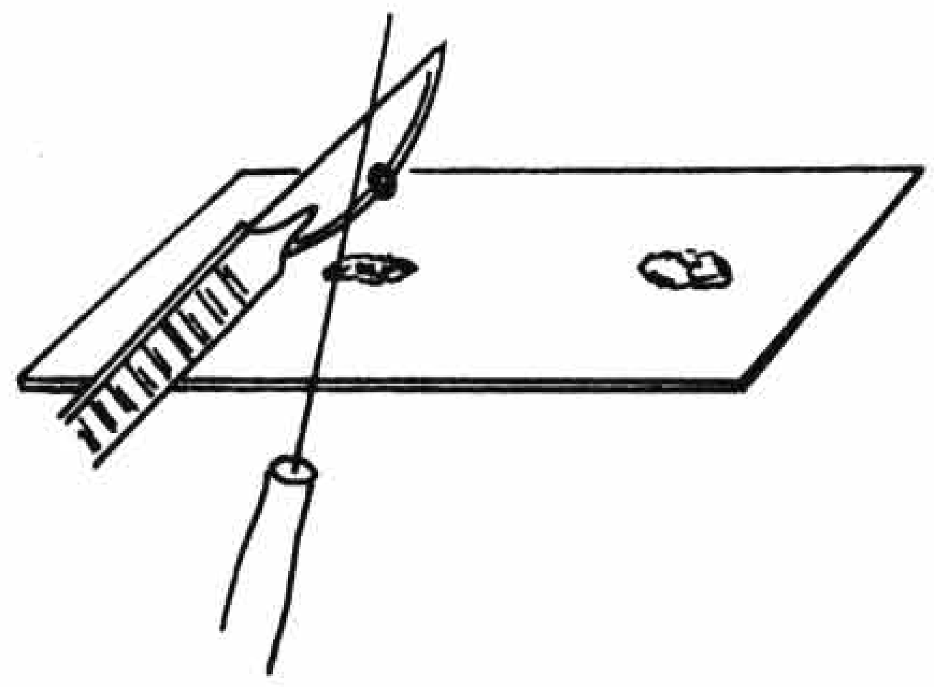
The fastest and surest way to kill a very sick fish is to cut deeply into its neck with scissors (*see Figure 1*).

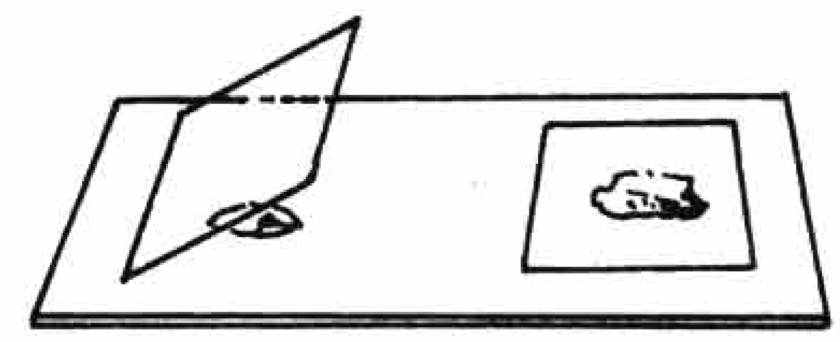


To detect pathogens on skin or gills, a skin smear can be taken, or a piece of fin cut off. Skin smears are obtained by carefully scraping off the mucus layer with a scalpel. The smear or piece of fin is placed into a drop of aquarium water on a slide and covered with a cover slip.

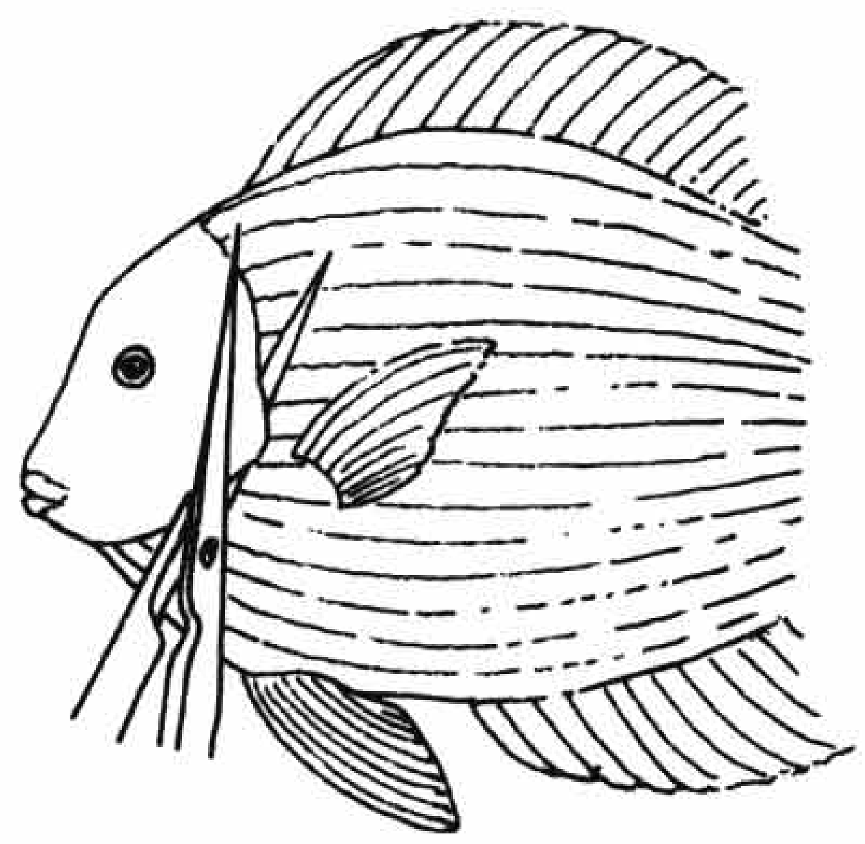


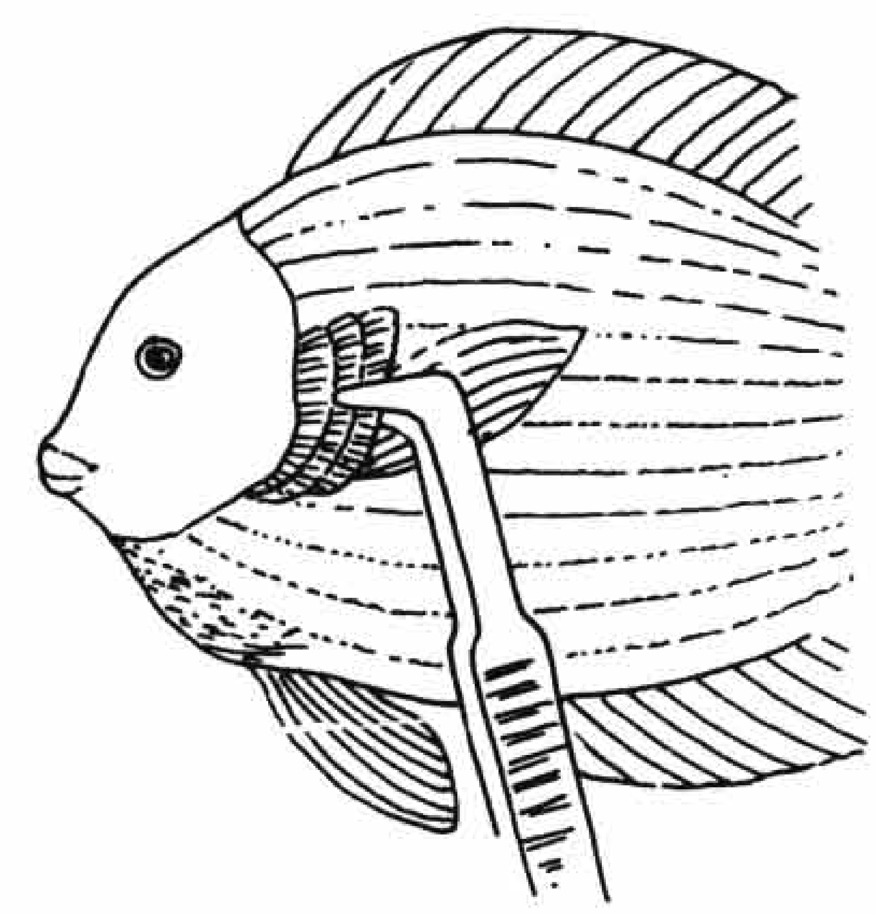




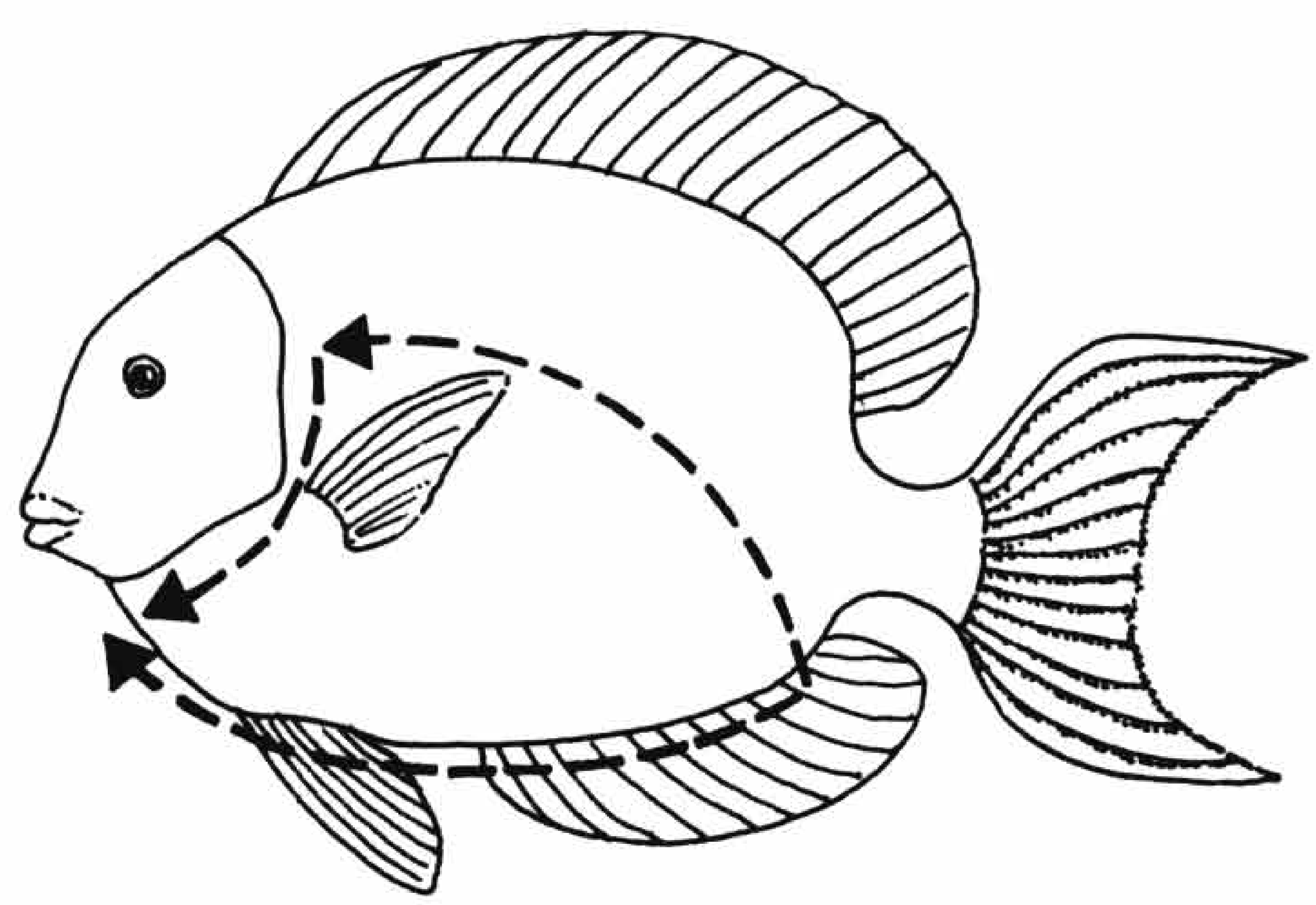


Afterwards, the gill cover can be cut away to expose the gill. Sample gill tissue can be removed with the scissors or pincers and placed into a drop of seawater on a slide and covered by a cover slip.





If necessary, the fish can be dissected:



(1) Cut the stomach open, with scissors, from anus to gills without damaging the internal organs. (2) Then, beginning with the anus, open up the side of the fish to the edge of the gill cover. (3) After removing cut skin, the internal organs are exposed for examination.
If small pieces of intestines, liver etc. are pressed in small quantities of water between slide and cover glass they can be examined under the microscope.

2. Viral infections

Very little is known about viral infections in tropical marine fish. There are probably various, unidentified viruses which cause clinical symptoms similar to those caused by bacterial infections. Some viruses can even lead to tumors.
However, *Lymphocystis* has typical clinical manifestations and can be clearly identified.

Lymphocystis

This virus primarily attacks skin and fin tissue (also mouth and gill cover). Infected cells develop into giant cells and are manifested in nodules (*Figure 6*). Consequently this is also known as *nodule disease* (*Figures 4, 5*).
This infection occurs regularly in marine fish if they are treated roughly or transported under very stressful conditions. This viral infection is often found in the weeks after heavy storms, which means stress for the fish. Excessive treatment with copper sulfate can also give rise to this infection. Irritated skin and fin tissue become more susceptible to this virus. Some kinds of fish, such as Butterflyfish (*Chaetodon sp., Forcipiger sp., Heniochus sp.* etc.), Emperorfish (*Pomacanthus sp., Holacanthus sp., Centropyge sp.*), *Gamma loreto* etc. regularly contract this disease. Certain fish types in an aquarium may have this disease while others in the same aquarium do not.
Initially only a few small white spots (especially on the fins) are seen. These are easily mistaken for white spot disease of marine fish (*Crypto-caryon*) and so can be treated incorrectly. Sometimes the infection simply disappears, but it can also develop into a secondary bacterial infection and finally result in death. In the final stage of infection, the diseased fish have massive cauliflower-shaped tumors.
When these develop on the fish's mouth, food intake is prevented and the fish starves.

Figure 4

Lymphocystis on the tail of a young Emperorfish *(Pomacanthus imperator)*

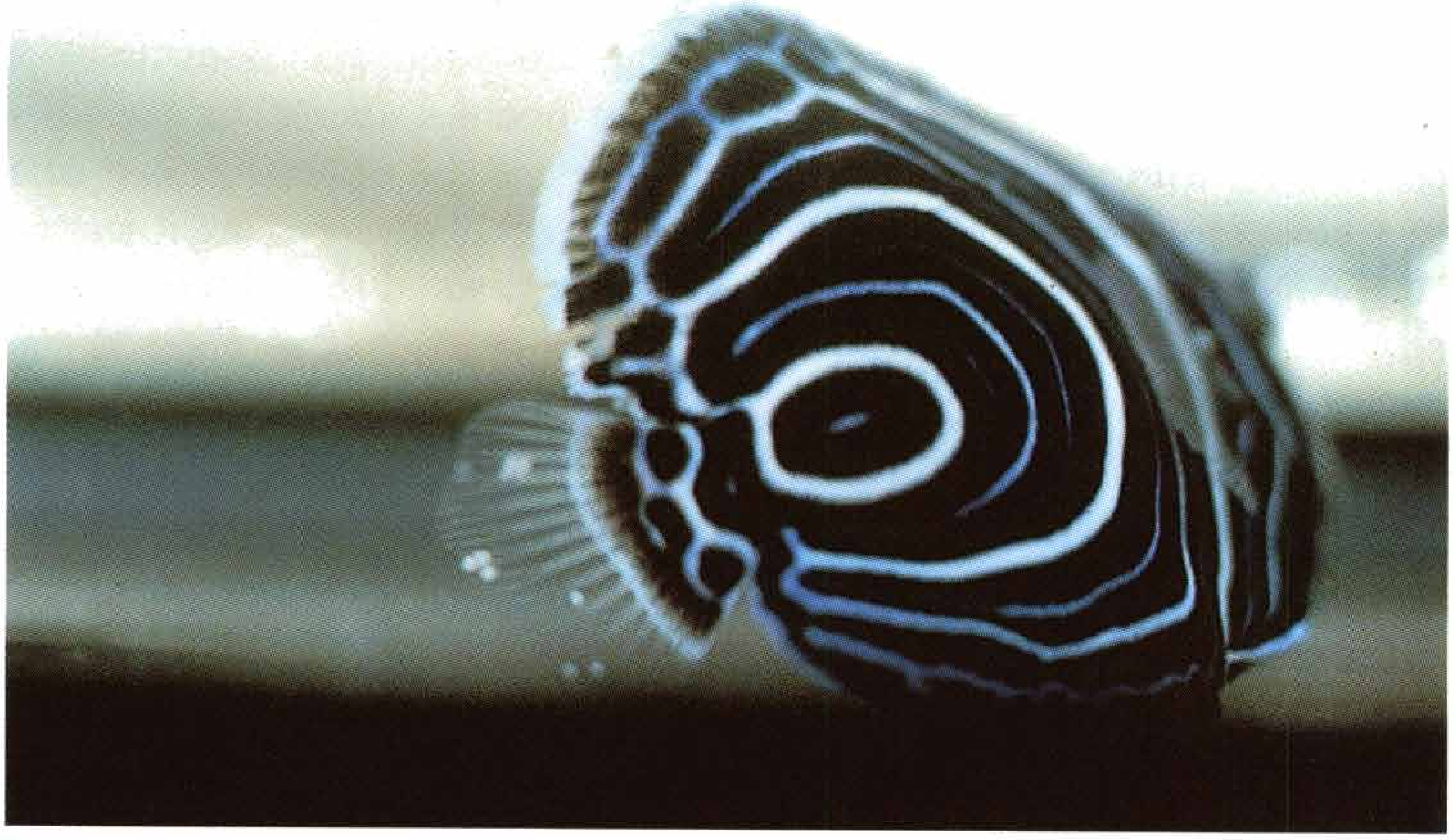
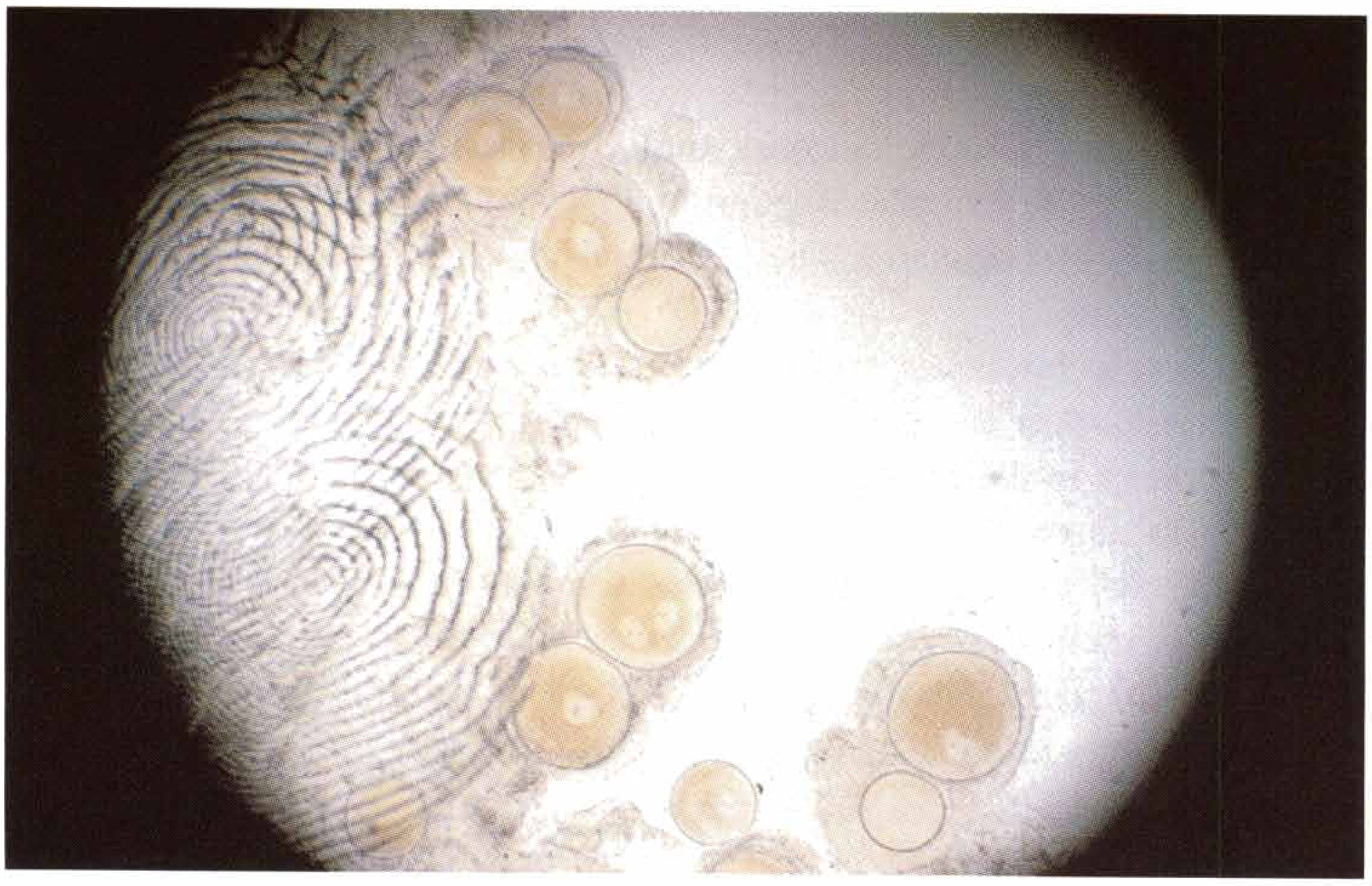


Figure 5

Lymphocystis infection on the tail, back, anus and pectoral fins of a Wimplefish *(Heniochus acuminatus)*.

Figure 6

A microscopic photograph (100x magnification) of white nodules or giant cells caused by the *Lymphocystis* virus.



Treatment

There are no specific drugs for treating *Lymphocystis*. Sometimes it disappears on its own. However, the first nodules should be carefully scraped off with a fingernail or a small knife and the wounds treated with mercury-chromium (4 %) or another disinfectant. In severe cases, it may be advisable to simply cut off any infected fin parts and disinfect the sites. In special aquaria, fish can also be treated with antibiotics or chemotherapeutics against secondary infections. After a time, fins usually regenerate. Good results can also be obtained by placing iodine (e.g. potassium iodate) into a separate tank containing water or brushing iodine onto the infected areas.

If this viral infection cannot be attributed to overdoses of copper sulfate, treatment with copper sulfate or formaldehyde — copper sulfate may be effective. In some cases, however, the disease recurs after a few days.

3. Bacterial infections

It is important to determine exactly which bacteria are responsible for a particular bacterial infection. This is achieved by growing laboratory cultures. In addition, tests should be performed on cultivated bacteria to determine how they react to potential antibiotic and chemical treatments. Usually, tests such as these require time and experience before any results are obtained. In other words, it is usually too late to save infected fish. For this reason, we use another simple method for treating bacterial infections i.e. we administer broad spectrum antibiotics in order to simultaneously fight as many bacteria as possible (*Figures 7 and 8*).

At the same time, scientific determination and sensitivity tests can be carried out.

If no improvement is observed after two or three days' treatment with one broad spectrum antibiotic, another antibiotic should be used (after replacing the water). We can also attempt to find the cause, while in the meantime, laboratory examinations may have provided information on the kinds of bacteria present.

It is extremely important to note that when drugs are introduced into a common aquarium to treat bacterial infections, *Nitrosomonas* and *Nitrobacter* bacteria in the biological filter bed are also killed. There is no good information about which antibacterial drugs are associated with greater danger for nitrifying bacteria. However, we should always be aware of this risk. If this method is used, the ammonia and nitrite contents should be checked regularly to determine whether there are any fluctuations. The safest method is to put the fish into a quarantine tank and treat them there (or to cut off the biological filter and treat the aquarium).

Ultraviolet sterilization can also be used to control and reduce bacteria in individual aquaria or in several aquaria connected to a central filter system.

Figure 7

Local bacterial infection on gill cover (with hemorrhage) of an Emperor Snapper *(Lutjanus sebae)* before treatment with antibiotics.

Figure 8

Cured wound on the gill cover of an Emperor Snapper *(Lutjanus sebae)* three days after treatment with antibiotics.

Fin rot

The rotting (decay) of fin or tail edges caused by bacteria (*Figures 9, 10, 11*) is a frequent manifestation of bacterial infections.
This can be attributed to numerous bacteria (such as *Pseudomonas, Aeromonas, Edwardsiella* etc.). Skin and fin rot can also occur after parasitic diseases as bacterial secondary infections.
Initially, the outermost ends are infected. Normally, these tear or fray. If these symptoms are not promptly noticed or not treated, pieces of fin or tail may rot or fins or tails may fall off completely. If this occurs, no cure is possible.

Treatment

You must first determine whether parasitic infestation is the primary cause of the disease. If it is, then the parasitic infection must be treated. At the same time, secondary bacterial infections must also be treated. Use the effective antibacterial agents, such as erythromycin, nifurpirinol, neomycin, Linco-Spectin®, or also combinations such as neomycin-nifurpirinol.

Figure 9

Bacterial infection accompanied by fin rot, white skin spots, scale loss and lying on the bottom of the aquarium all on a violet *Pseudochromis.*

Figure 10

Fin rot on a Coral Beauty *(Centropyge bispinosus).*

Figure 11

Bacterial infection with fin rot as well as skin hemorrhaging on a Long Nosed Butterfly *(Forcipiger flavissimus).*

Red inflammations on skin and fins, including *Vibrio* infection

Initially, small red blood spots are observed. These may develop into large bloody spots or even ulcers. Fin rot may also occur (*Figures 11, 12, 13 and 14*). In many cases, this clinical picture can be attributed to bacteria, but some parasitic infections such as *Brooklynella* and *Uronema* produce similar symptoms. The anus is sometimes bloody and swollen. In severe cases, muscular tissue may also be infected in which case a cure is practically impossible and it is recommended to allow the fish to die painlessly.

In addition to the red spots, infected fish may also behave abnormally, breath heavily, lie on the surface of water or lie on the floor of the aquarium. The fish become totally listless in the final stages. *Vibrio, Pseudomonas* or other bacteria can cause such infections. *Vibrio* corresponds to the freshwater *Aeromonas liquefasciens*.

Treatment

Antibacterial preparations such as nifurpirinol, sulfonamide, kanamycin or streptomycin. Before starting antibacterial treatment, you should determine whether there are primary parasitic infections.

Figure 12

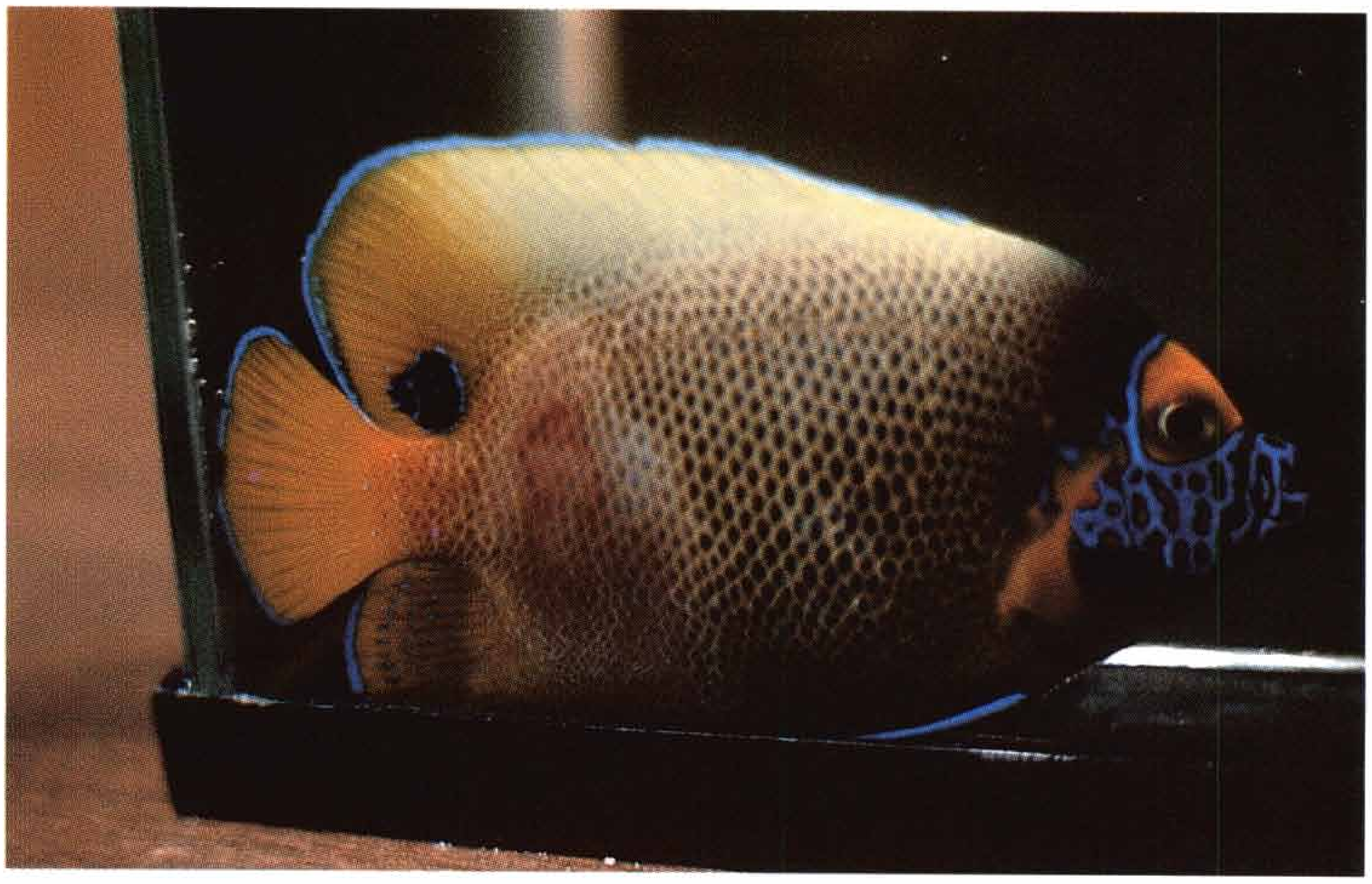
Red skin patches (hemorrhage), caused by a *Vibrio* infection in a *Chaetodon octofasciatus*.

Figure 13

Red skin inflammation with abscess formation in a *Mirolabrichthys sp.*

Figure 14

Skin hemorrhaging with pale skin patches, caused by a bacterial infection in a Blue Face Angelfish *(Euxiphipops xanthometapon)*.



White skin patches, or patch disease

Fish show small or larger pale white skin patches from which the mucosa begins to loosen. Fin rot may also occur. Infected fish exhibit elaborated respiration (bacterial infections in the gills) hanging at the surface of the water or laying on the bottom of the aquarium (*Figure 9*). The head and eyes are often infected, in which case cloudiness of the eye occurs.
In some cases, this disease develops like *Brooklynella* or *Uronema* infections, with typical white skin patches; if this happens, it is caused by parasites. Sometimes, the pathogen is a *Myxobacterium*, *Flexibacter sp.*, which corresponds to *Columnaris* disease in freshwater fish. When the pH level is too low, similar symptoms may occur in which the mucosa hangs in strings from the fish and there are light colored patches on its skin (*Figure 15*).

Treatment

The actual pathogen must be determined. Bacterial infections are treated with neomycin, nifurpirinol or combinations of neomycin-nifurpirinol.

Figure 15

Pale skin patches with skin loss and fin rot, caused by myxobacteria *(Columnaris Sp.)* in an Achilles Tang *(Acanthurus achilles)*.

Raised scales and/or swollen belly, ascites, dropsy

This disease is usually caused by *Pseudomonas, Corynebacterium sp.* At first, raised scales appear on individual parts of the body. Later these spread over the entire body. Ascites is another typical symptom, very similar to ascites in freshwater fish. Sometimes, bloody spots appear. When fish develop ascites, there is very little chance of survival. Kidneys are often affected (*Corynebacterium sp.*), causing fluid retention.

Treatment

Prophylactic treatment, with for example, erythromycin, nifurpirinol, or tetracycline, is strongly recommended.

Swim bladder inflammation

One typical symptom of this disease is the abnormal swimming behavior of the fish. Since the swim bladder can no longer fulfill its balancing function satisfactorily, fish are unable to remain suspended and they try desperately to remain in equilibrium. This is also a symptom of fish tuberculosis.

Treatment

Sometimes, increasing the water temperature by a few degrees and soaking foodstuff in antibacterial drugs (e.g. tetracycline) can improve the condition, although the prognosis is not good.

Fish tuberculosis: *Mycobacterium* infection

This stubborn bacterial infection is caused by *Mycobacterium marinum*, which corresponds to the *Mycobacterium* infection in freshwater fish. Symptoms vary: weight loss or swollen belly, white skin patches and scale loss, protruding eyes, fin rot, skin ulcers. Fish are usually listless, lose their appetite and quickly lose weight (*Figures 16, 17*). Fish which are poorly kept and incorrectly fed tend to suffer from this particular disease. Very often, infection occurs in older fish which have been kept for several years. Deformation of the skeleton is a frequently occurring associated symptom. When examining infected fish, small grayish brown nodules are found in the internal organs. These are tubercles, which are very typical for this disease and which serve as a diagnostic indication. However, these should not be confused with internal fungal infection (*Ichthyophonus*), in which similar nodules occur. Examining a crushed preparation of the infected organs aids correct diagnosis (*Figure 18*).

Treatment

Usually, infected fish have to be removed from aquaria and, if necessary, painlessly killed. Treatment with kanamycin, streptomycin, isoniazid or rifampin seldom yields results. UV sterilization of aquaria (or closed systems) helps to stop the *Mycobacterium sp.* from spreading.

Figures 16 and *17*

Fin rot, scale loss, decoloration and exophthalmos (popeye) due to marine fish tuberculosis *(Mycobacterium marinum)* in a Green Damsel *(Chromis caeruleus).*

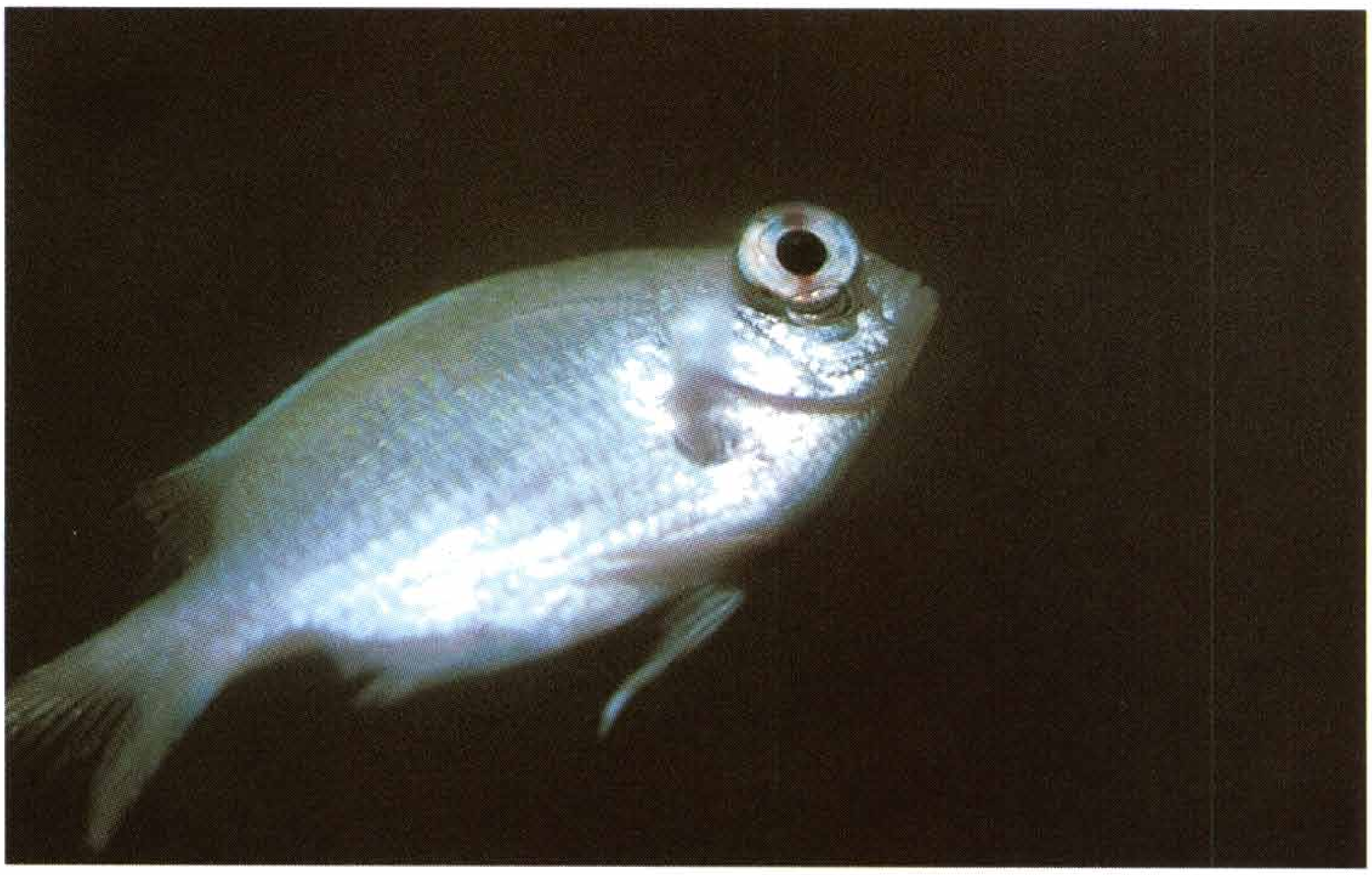
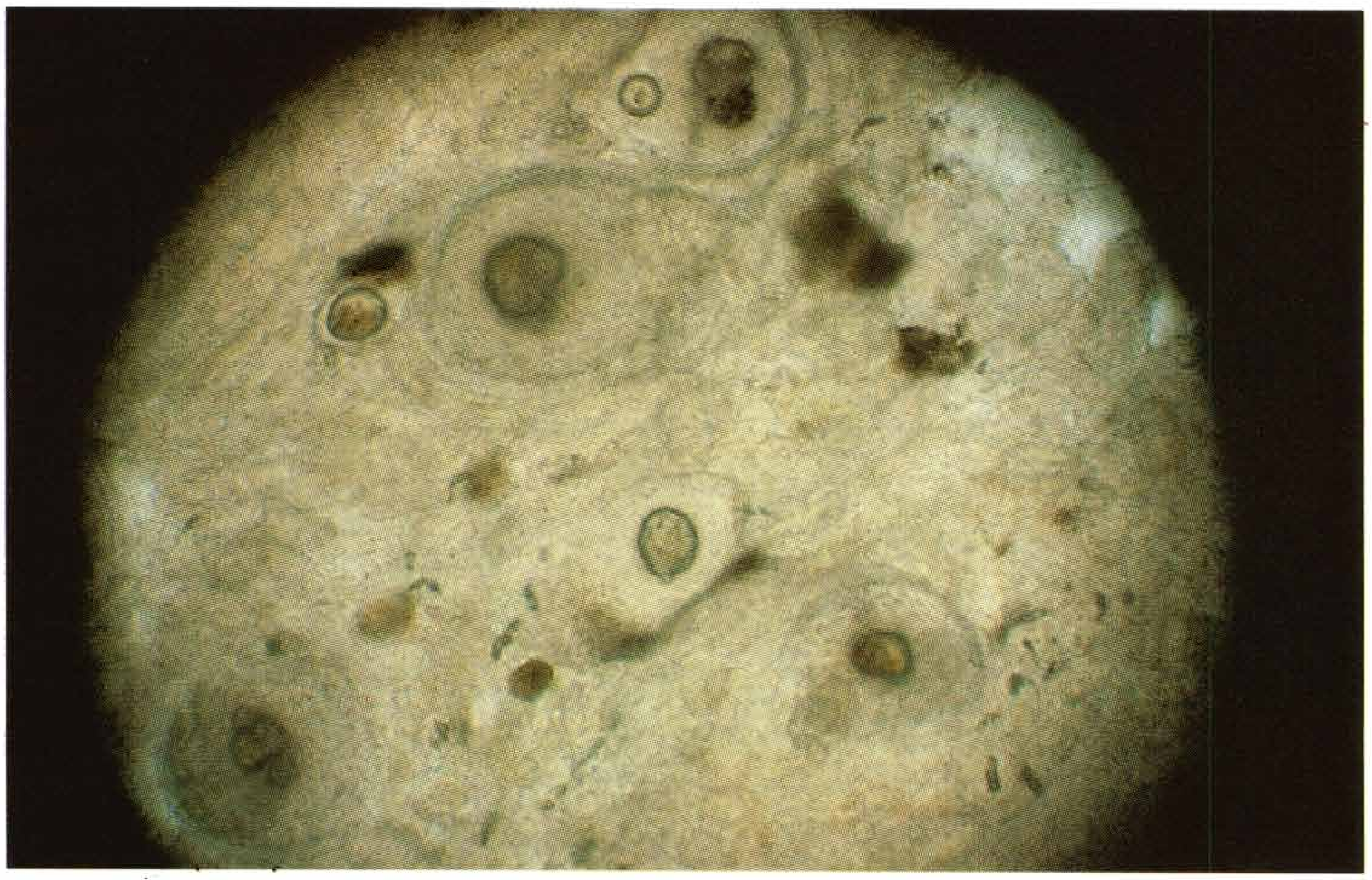


Figure 18

Tubercles of marine fish tuberculosis *(Mycobacterium marinum)* in the liver of a Green Damsel *(Chromis caeruleus).*



Eye cloudiness

Eye cloudiness or mucus formation on the eye occurs in different bacterial and parasitic infections (*Cryptocaryon, Brooklynella* etc.). Injuries incurred during transportation, dirty water and fights can facilitate these infections. In other cases, eyes protrude or are inflamed. There are many causes for this symptom.

Treatment

The first thing to do is to determine whether any environmental factors are causing these infections. Drug treatment is not always successful because damage may be irreversible. However, good results are sometimes achieved with neomycin, nifurpirinol, or sulfonamides.

4. Fungal infections

Two kinds of fungal infections occur occasionally in marine fish; an external infection, usually secondary, caused by skin fungi such as *Saprolegnia sp.* comparable with *Saprolegnia sp.* in freshwater fish, and an internal infection. Here, the pathogen is *Ichthyosporidium hoferi* (formerly *Ichthyophonus hoferi*) as in freshwater fish.

External fungal infection (skin fungi), *Saprolegnia sp.*

This disease occurs less frequently in marine fish than in freshwater fish. It is caused by *Saprolegnia sp.*, which corresponds to *Saprolegnia sp.* in freshwater fish. This fungus usually infects fish after the skin or fins have been damaged by bacterial and/or parasitic infections, poor living conditions such as dirty water, poor filtration, or excessive organic waste. Healthy fish are rarely infected by these fungi. When the protective mucosa is damaged, fungi can penetrate the skin, producing a coating or cotton-swab-like formations (*Figures 19 and 20*).

Treatment

It is essential that the true primary cause for fungal infections be found and completely eradicated. Pure seawater with good filtration may be sufficient to impede fungal growth. Also, treatments in the early stages with preparations such as nifurpirinol, malachite green, copper sulfate or phenoxyethanol are very effective.

In cases of primary bacterial infection and secondary fungal infection, an effective antibacterial drug should be administered first. In the case of parasitic infections, parasites must be eradicated first or simultaneously with secondary infections.

Figure 19

Fungal infection (brown coating) on the side of a pink Skunk Clown *(Amphiprion perideraion)* after injury.

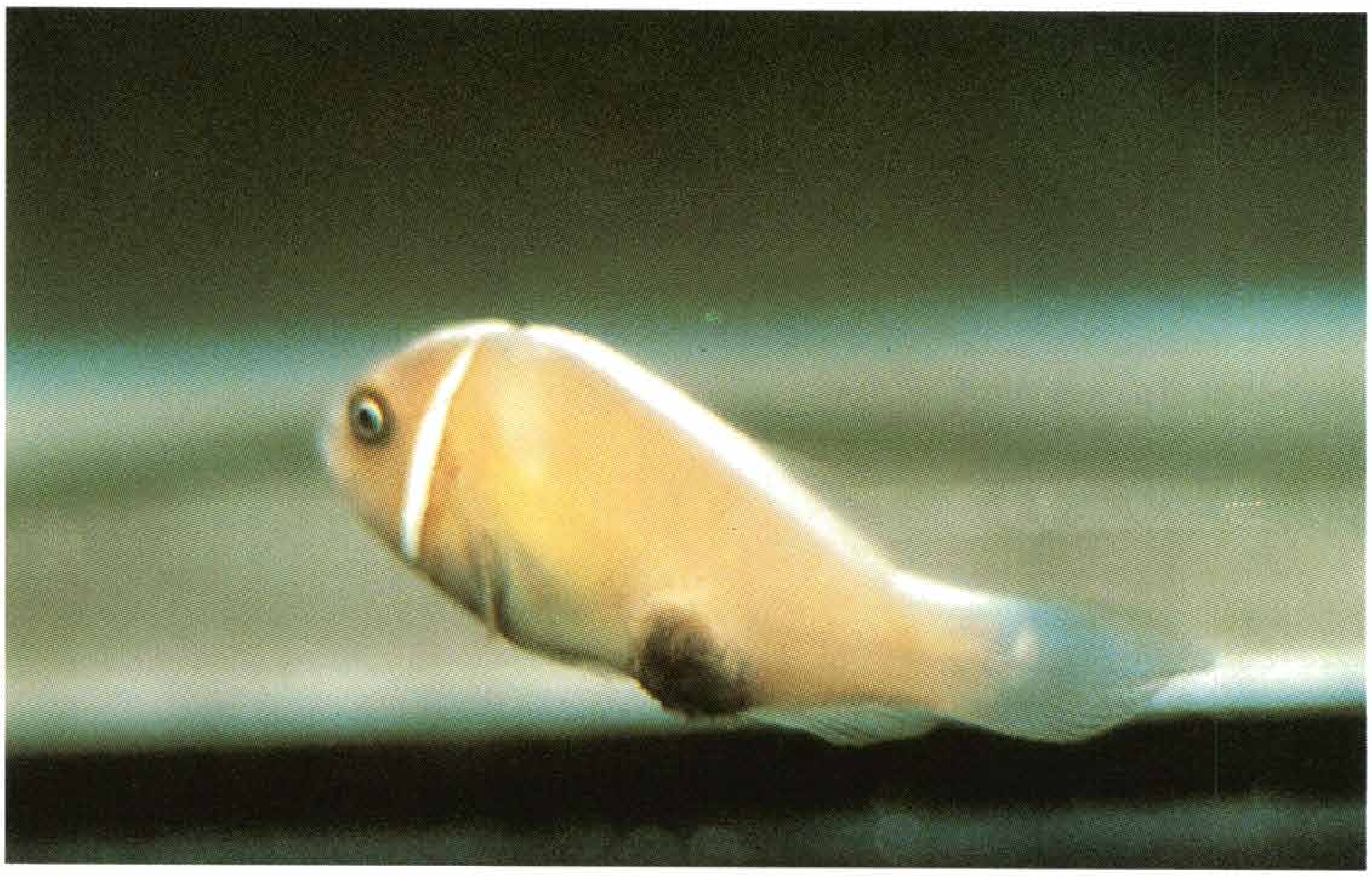
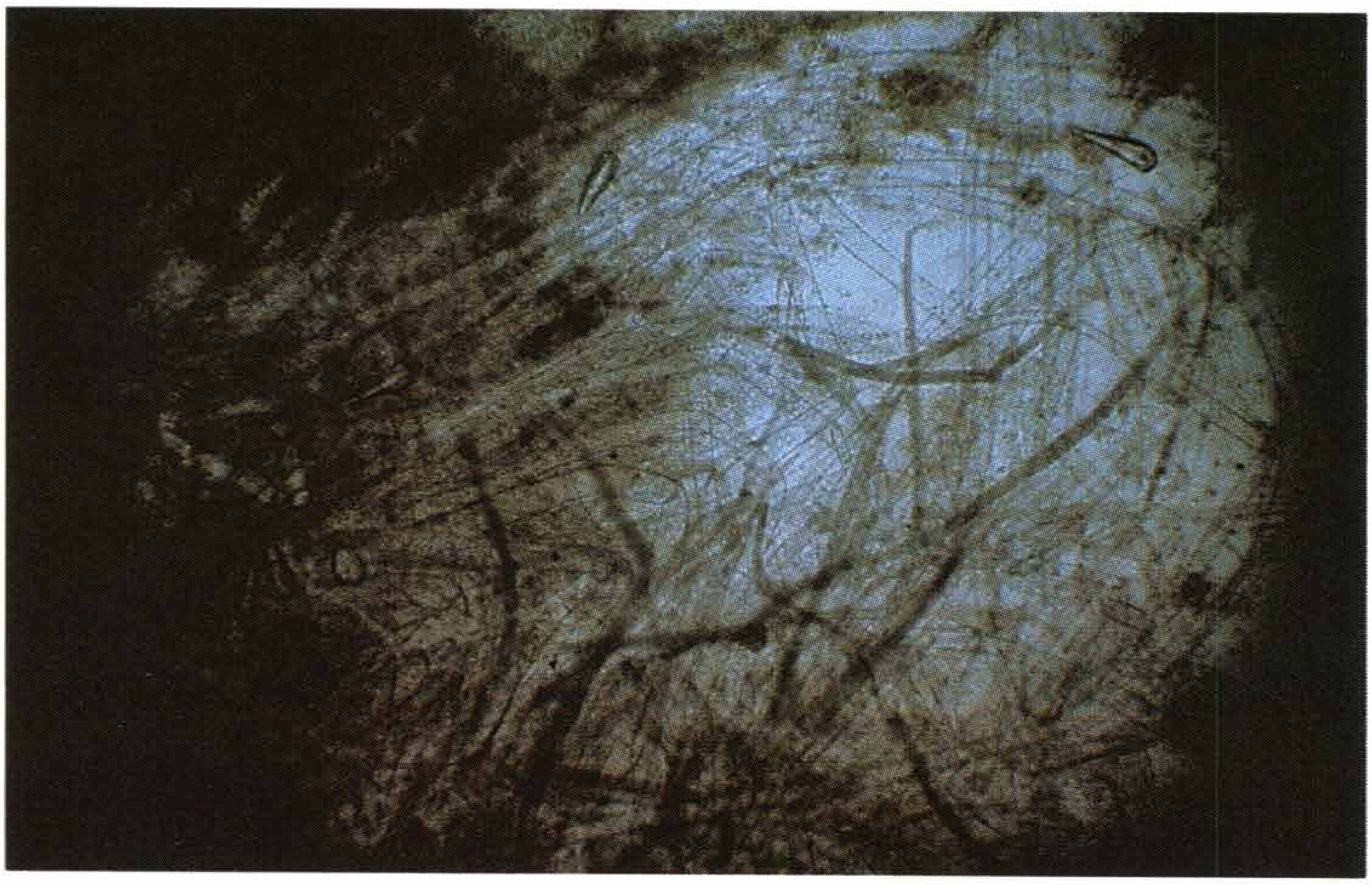


Figure 20

Macroscopic magnification (100x) of a fungal infection, with typical fungus threads.



Internal fungal infection: *Ichthyosporidium hoferi*

This fungus affects internal organs and, based on my observations, occurs more often in marine fish than it does in freshwater fish. This is the opposite to the situation with external fungus diseases.
At first, no external symptoms are observed. Unfortunately, symptoms are only observed in the later stages of the infection, i.e. when the fish can no longer be saved. Infected fish lose weight rapidly, swim abnormally, their eyes protrude, dark spots appear on their skin (*Figure 21*), fin tissue is damaged and secondary bacterial infections may occur causing pale or red skin patches. Ichthyosporidium infections are detected by examining crushed preparations of internal organs such as liver, kidneys or spleen (*Figure 22*). In some cases, organs can encapsulate fungus parasites. The infection is transmitted through infected feeder fish.

Treatment

High-quality food and a healthy environment are the fundamental keys to avoiding this fungal infection. Phenoxyethanol added to food is an effective treatment and prophylactic measure, although the results are not always satisfactory. Infected fish must be isolated and you can only hope that other fish are not infected.

Figure 21

Rock Beauty *(Holacanthus tricolor)* with exophthalmos, here caused by an internal fungal infection *(Ichthyosporidium hoferi)*.

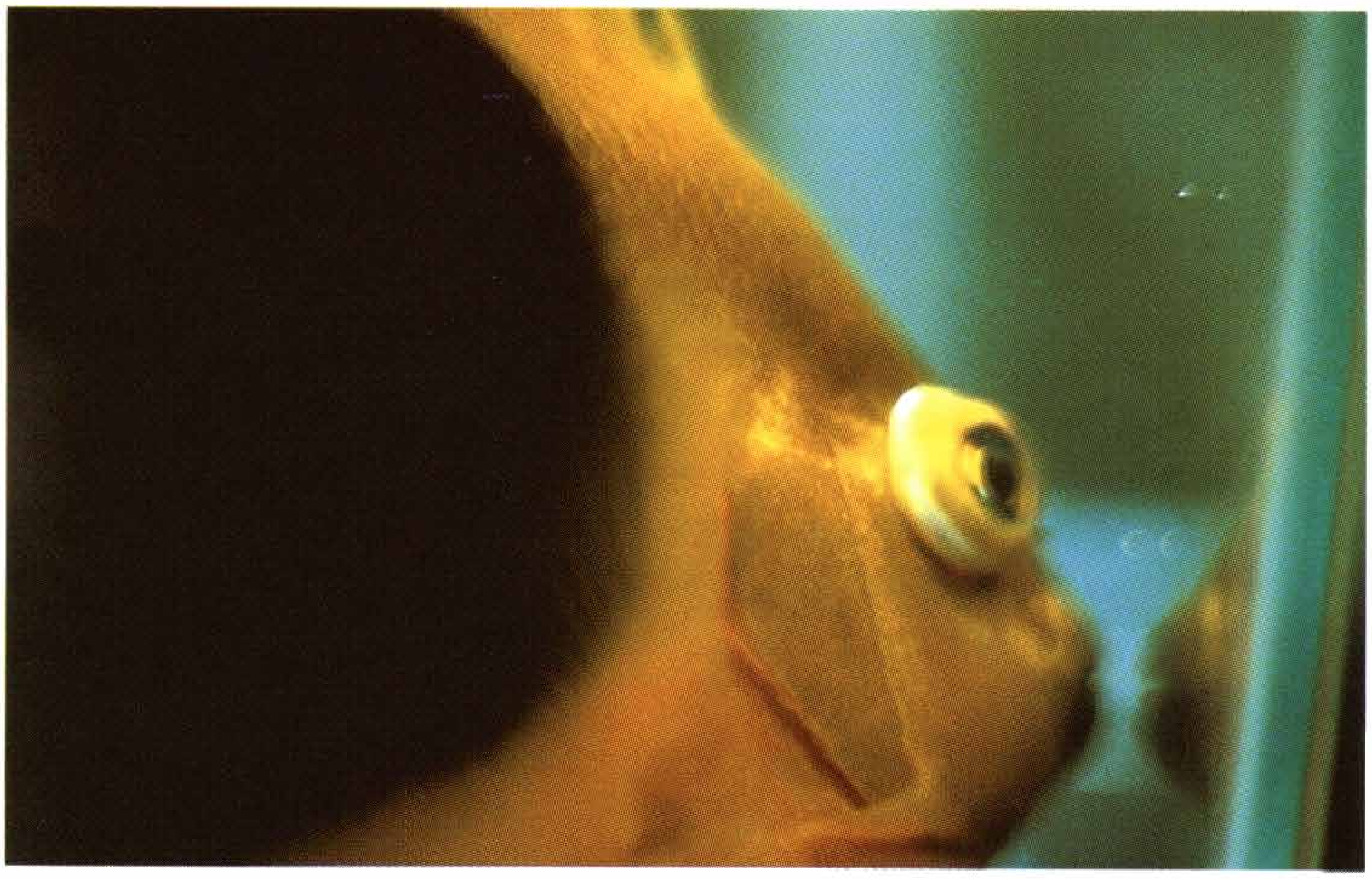


Figure 22

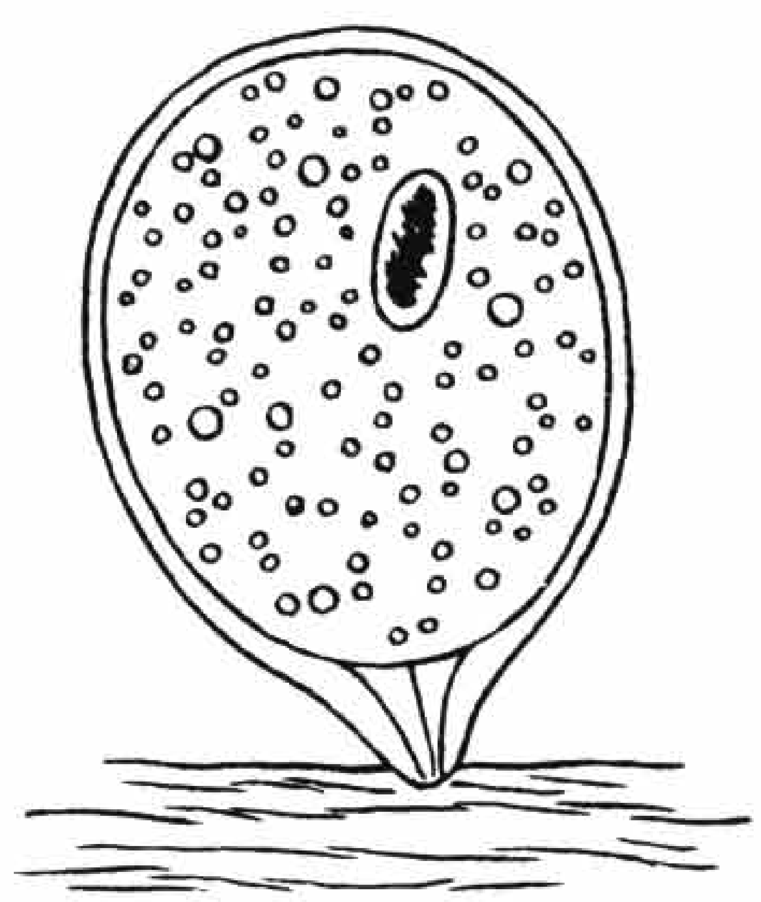
Ichthyosporidium hoferi or internal fungal infection in the liver of a marine fish.

5. Parasitic infections

5.1. Protozoa or unicellular parasites

Tropical marine fish can become infected by the following single-cell animals: flagellates which move or attach to the host with flagella, ciliates which move and feed with cilia and sporozoans, unicellular parasites which are not mobile but are transferred with water or food. Depending on the type of parasite infecting the fish, diseases are more or less typical, and are easier or more difficult to cure.

Oodinium infection (or Marine Velvet Disease, Amyloodinoisis or Coral fish disease): *Amyloodinium ocellatum*



Amyloodinium ocellatum

Amyloodinium ocellatum belongs to Dinoflagellates. Its counterpart in freshwater fish is *Piscinoodinium pillularis*.

This infection is sometimes difficult to diagnose, depending on the incidence angle of light and the angle at which we observe the fish. Moreover, *Amyloodinium* parasites primarily attack gills (*Figures 23* and *24*). In advanced infections, skin and fins are also involved. Very fine whitish yellow spots (a salt and pepper coating) can be seen, which are particularly prominent on the fins.

These unicellular parasites (size 50-60 µm) anchor themselves into the mucosa by their rhizoids or 'roots' (*Figure 25*). With these root-like structures, parasites gain a firm hold of their hosts and cause the greatest damage to the mucosal layer. As a result, the fish's defense mechanism is weakened and they become susceptible to secondary infections recognizable by red bloody skin patches. Treatment is not usually effective. These parasites are sometimes found in the kidneys.

Infested fish are restless, suffer from difficult respiration, rub their bodies on the bottom of the aquarium or on corals, hang at the surface, gasp for air and sometimes simply lie on the bottom of the tank. *Amyloodinium* parasite can be easily seen on skin or gill smears under the microscope (x 100 or x 200 magnification). They look like dark cone-shaped unicellular organisms in tissue (*Figure 26*). Knowledge of their life cycle is essential for proper treatment. *Amyloodinium ocellatum* appears as cysts on fish. After several days, the parasites drop off the host and divide into numerous daughter cells (*palmella* stadium) in the aquarium. Each daughter cell forms a flagellum and swims away (*dinospores*). To survive, these spores have to find hosts within 24 hours. Consequently, it is of paramount importance in treatment that these free-swimming spores be killed quickly. Since exporters, importers, wholesalers, retailers and fish hobbyists often treat their fish with copper sulfate, *Amyloodinium ocellatum* does not often appear. The parasites are killed and so do not make their way into aquaria.

Treatment

Since this parasite is easily transmitted, the entire aquarium, including fish and objects in the aquarium, should be treated. Copper sulfate is very effective. WATCH OUT! It kills or harms invertebrates! However, the solution must be strong enough and must contain at least 0.20 ppm of copper ions. It should be used for at least 8 to 10 days so that all (new) freely swimming spores are killed. If the salt content is also gradually lowered to 1.015-1.016 g/ml, parasites have even less chance of survival.
Quinine hydrochloride can also be used. However, this treatment is not as good as treatment with copper sulfate. Nevertheless, quinine hydrochloride is less toxic for fish and less damaging for nitrifying bacteria, but could be very toxic for several invertebrates and algae.
In addition to treating the aquarium, any fish which are still healthy can be placed into freshwater baths.
Treatment is most effective in the early stages rather than at more advanced stages of disease. If the tissue has already been badly damaged by the parasites, secondary bacterial infections may occur. These should be treated with antibacterial agents (e.g. nifurpirinol, furaltadone, etc.).

Figure 23

Oodinium infection, coral fish disease, easily recognizable on tail and back fins of a Wimplefish *(Heniochus acuminatus)*.

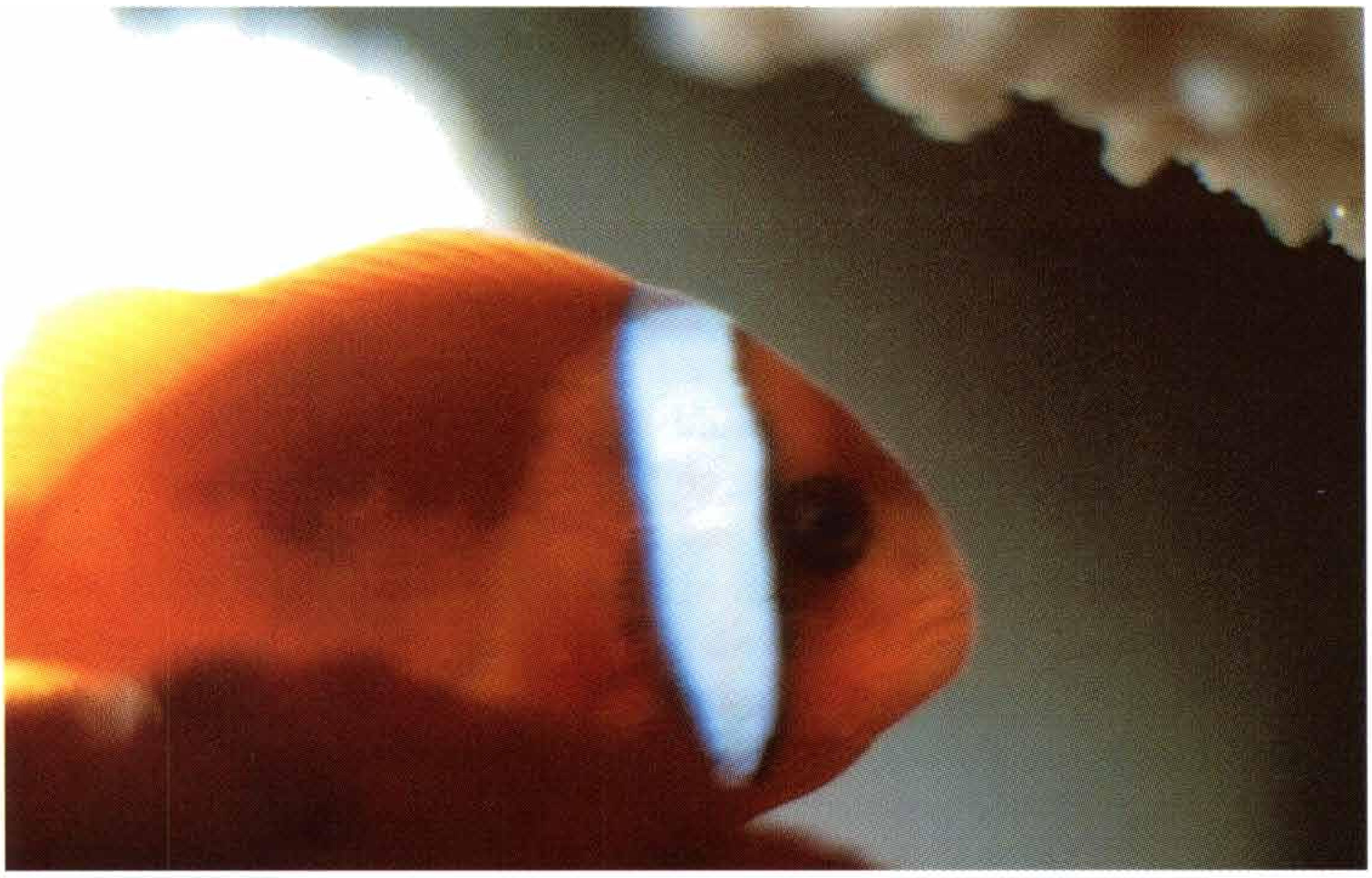


Figure 24

Oodinium infection in a Tomato Clown *(Amphiprion frenatus)*, which is almost not visible (depends on angle at which you look at it).

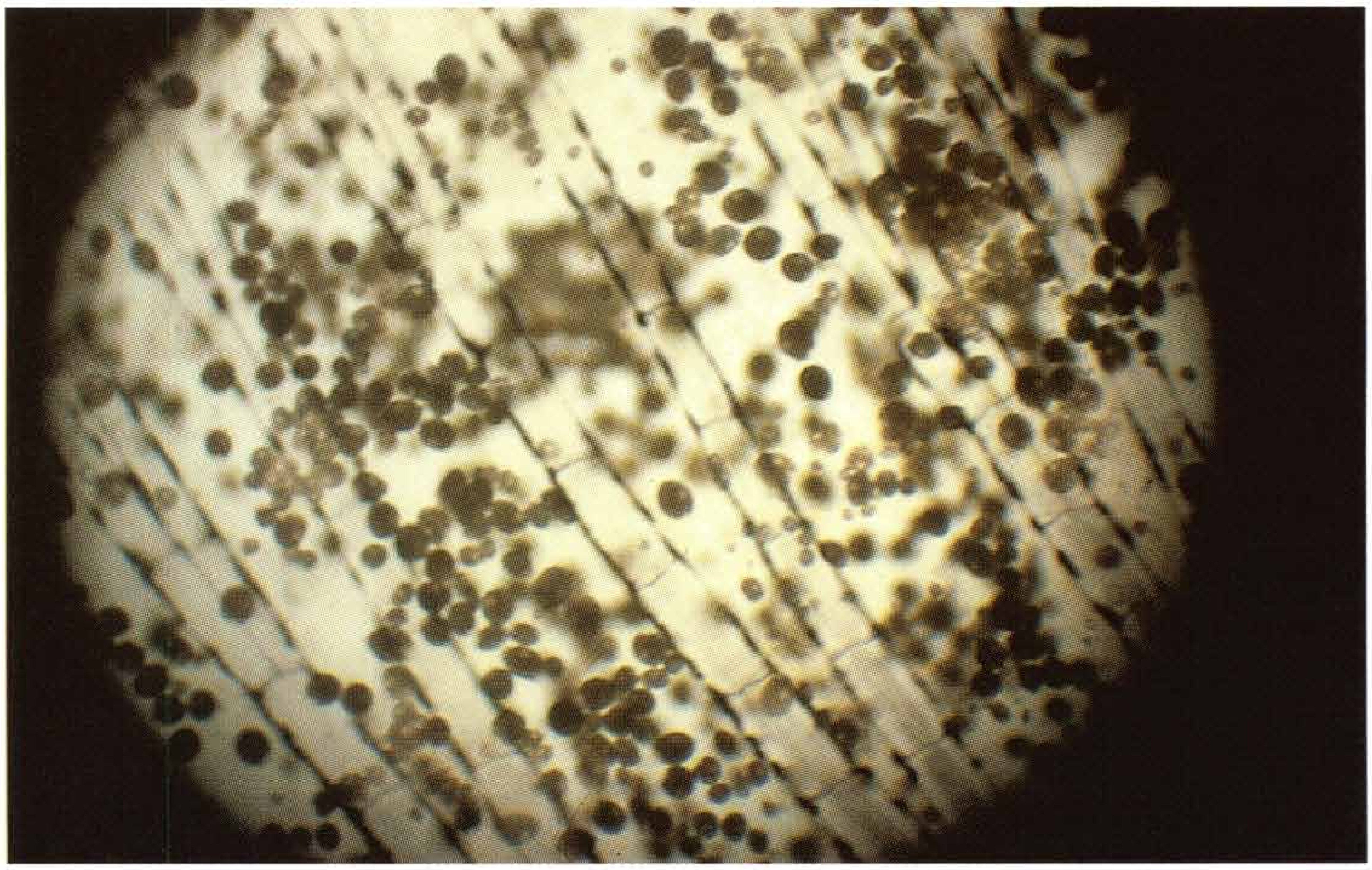


Figure 25

Microscopic picture (100x magnification) of a severe *Oodinium* infection on the tail fin.

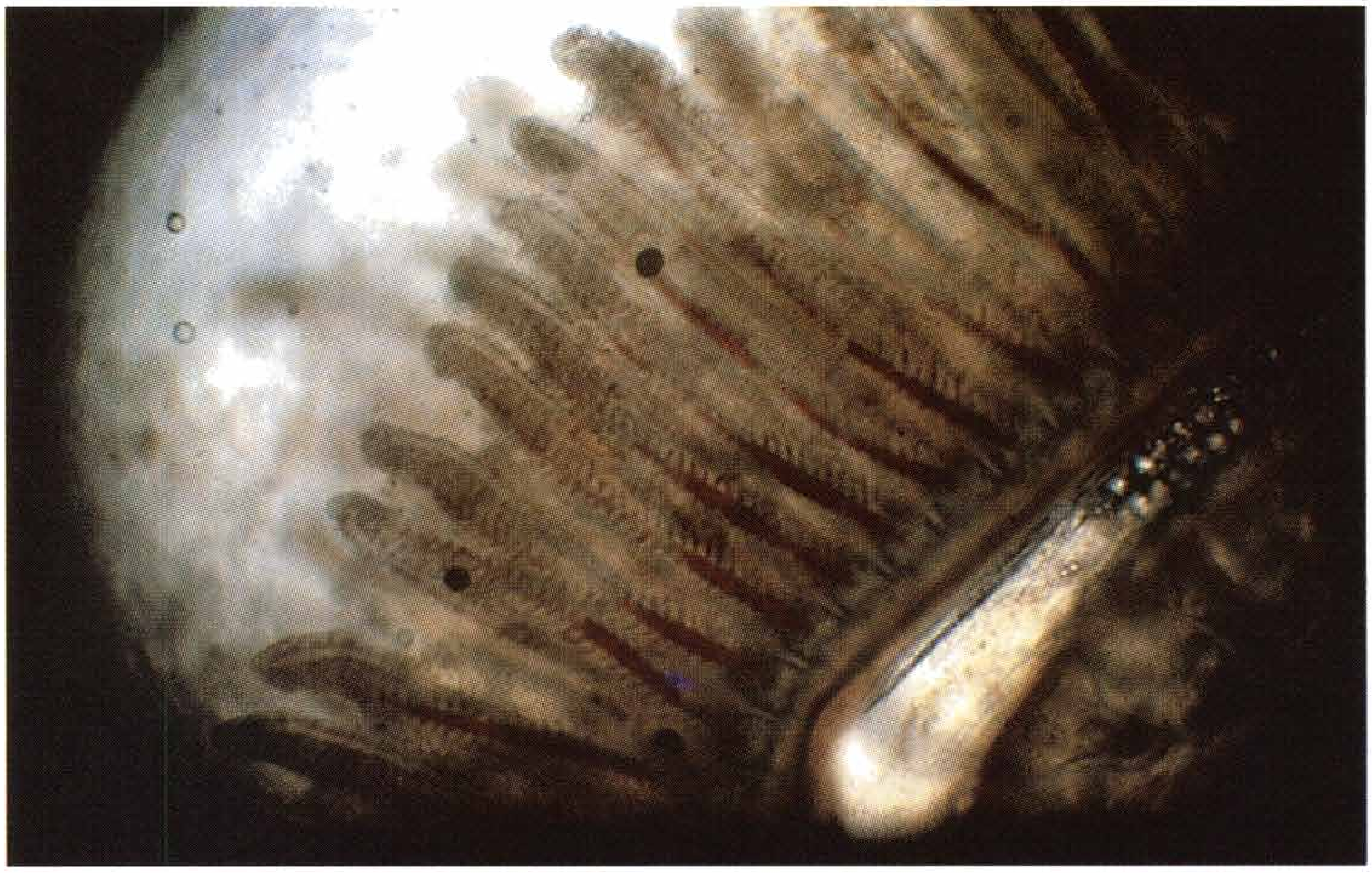
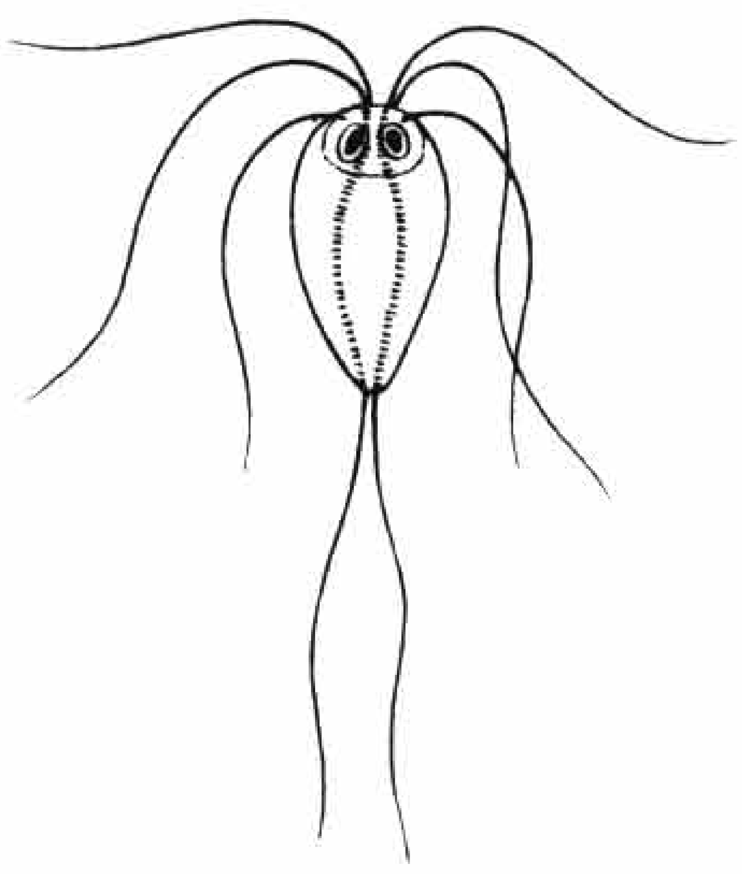


Figure 26

Amyloodinium parasites in gills (100x magnification).



Hexamita/Spironucleus

Hexamita/Spironucleus, 'hole-in-the-head disease' 'lateral line disease'

Until now, little has been published about this marine fish disease since it occurs only sporadically in the intestines and other organs of Angelfish (*Holacanthus sp., Centropyge sp., Pomacanthus sp.*) and Surgeons and Tangs (*Paracanthurus sp., Acanthurus sp., Zebrasoma sp.*) as well as in *Zanclus cornutus* (*Figures 27-31*).

The counterpart to *Hexamita/Spironucleus* is found in freshwater fish, especially in cichlids such as *Symphysodon discus*, *Pterophyllum scalare*, *Cichlasoma sp.*, in Kissing Gouramis (*Helostoma temmincki*), some tetras, catfish and other species (Bassleer 1983)[3].

This disease occurs especially in fish exposed to high level of stress. This might be caused by unclean living conditions, cold water, etc. There are no exact methods for determining the presence of this seawater flagellate, although it is very similar to the freshwater parasite *Hexamita/Spironucleus*. This also applies to *Spironucleus* and *Hexamita* which have not been clearly differentiated. Consequently, both names are used together. Infected fish lose their color, turn pale, progressively lose weight, become listless, lose their appetite and produce white slimy (sometimes aqueous) excretions (*Figures 29 and 30*). These latter symptoms are always observed in the case of bacterial or parasitic infestations such as those caused by worms.

In some extreme cases, 'hole-in-the-head disease' may develop, especially in larger, more adult, (*Figures 27 and 28*) marine fish. The combination of unfavorable environmental factors, unsuitable food and the presence of internal parasites (*Hexamita/Spironucleus*), may weaken the fish considerably. When this happens, the sensitive side organ, which runs into the mouth/snout area seems to weaken and to be damaged. Damage appears in the form of 'holes', caused by the loss of surrounding tissue, in which secondary bacterial infections can develop. So called 'lateral line disease'.

Initially, parasites settle in intestines irritating and injuring the intestinal walls, thus leading to increased mucus formation or diarrhea.

On microscopic examination (200x to 300x magnification) of fresh feces or the intestinal contents of dead fish, small, fast-swimming flagellates (size 6-12 μ) can be easily seen but should not be confused for male sperm (*Figure 31*).

IMPORTANT NOTE: Not all 'lateral line disorders' are originating from this parasitic infection. There seems to be many more (but unclear) factors that play a role in causing this disorder.

[3] Bassleer, G. (1983): Disease Prevention and Control. Freshwater and Marine Aquarium (FAMA) Magazine, Sierra Madre, CA, Vol. 6, No. 10, p. 38-41 and p. 58-60.

Treatment

Metronidazole in doses of 600-900 mg/100 liters of aquarium water is strongly recommended for three days. At the same time, nifurpirinol or nitrofurazone can be administered against secondary bacterial infections. Metronidazole can be mixed into the food of those fish which are still eating. After treatment, fish may still have holes which form permanent scars.

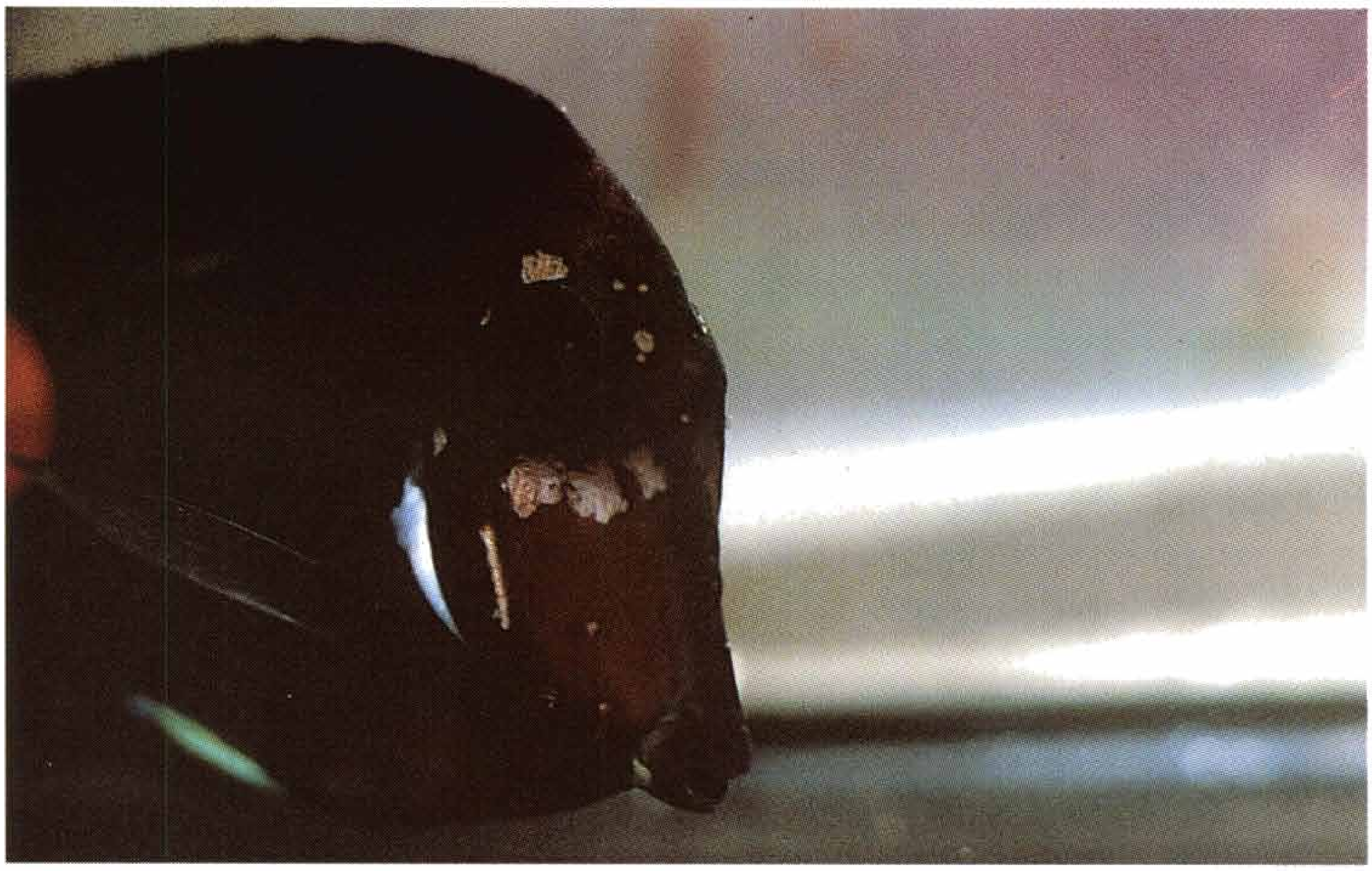


Figure 27

So-called "hole-in-the-head disease" of an Achilles Tang *(Acanthurus achilles)*.

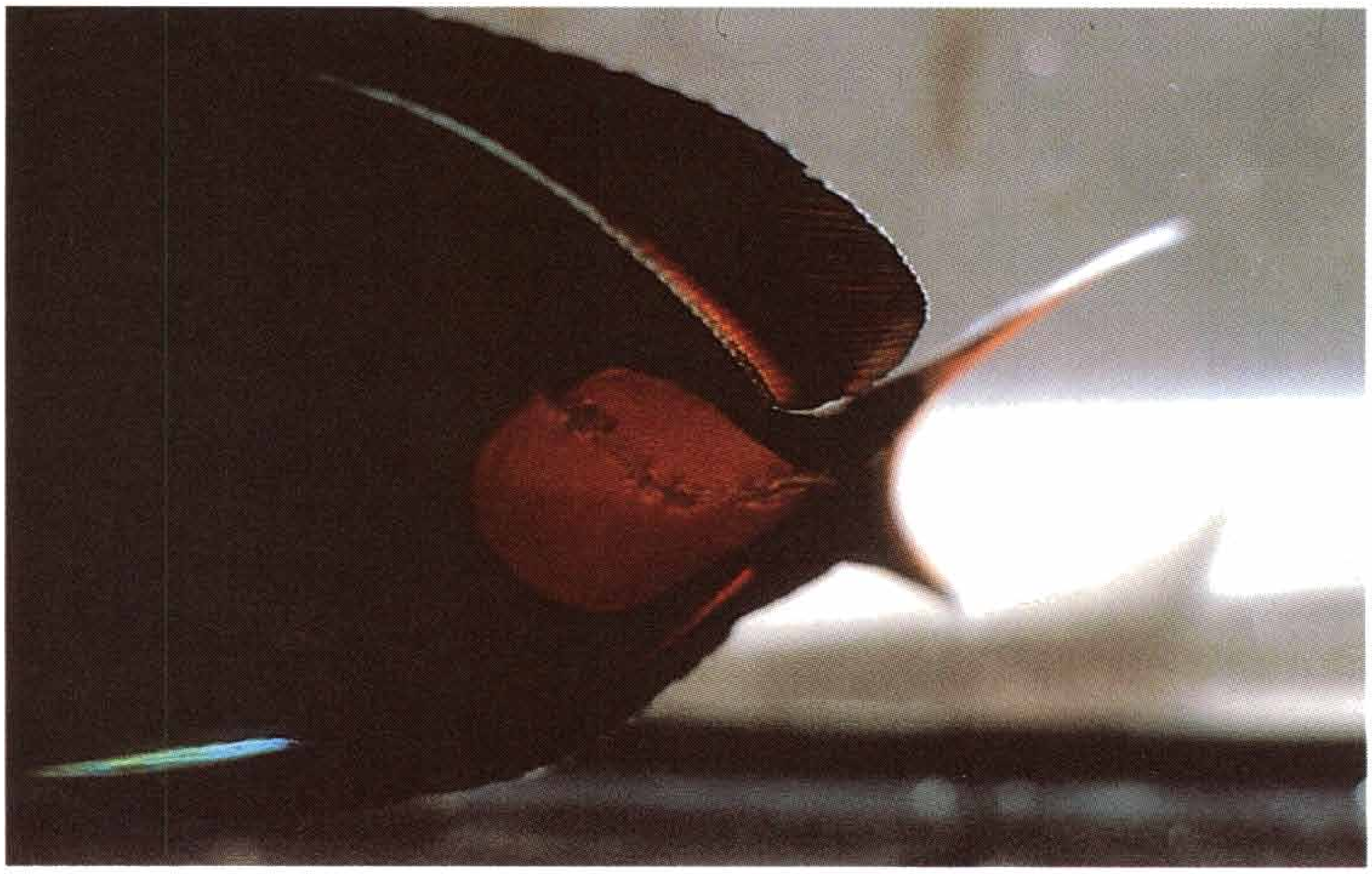


Figure 28

Erosion or dissolving of the lateral line organ in an Achilles Tang *(Acanthurus achilles)* with so-called "hole-in-the-head disease".

Figure 29

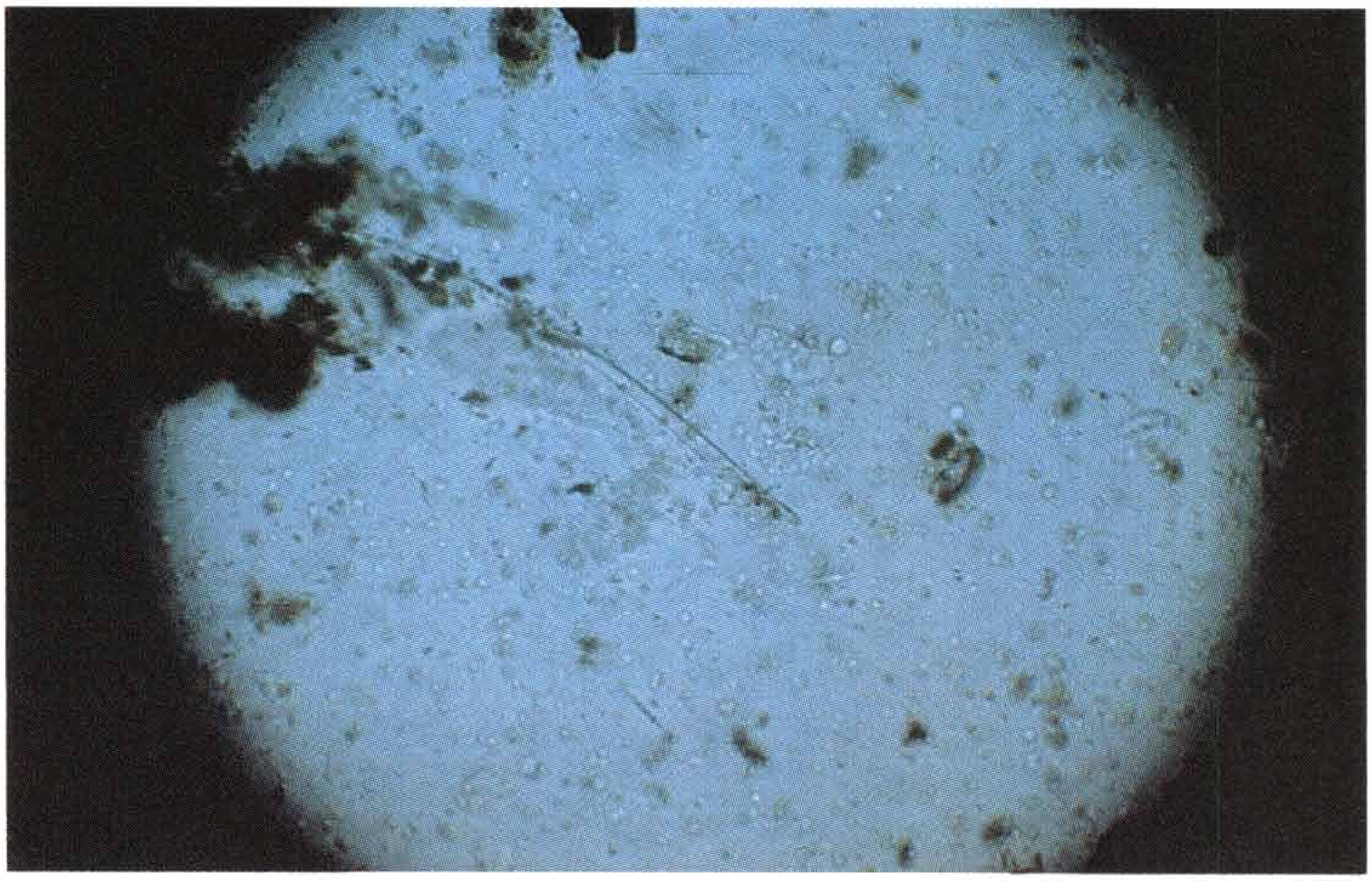
Coloration with secondary bacterial infection (fin rot) and erosion of the lateral line organ in a Koran Angelfish *(Pomacanthus semicirculatus)* with *Hexamita/Spironucleus* infection.

Figure 30

Initial stage of so-called "hole-in-the-head disease" in a *Hexamita/Spironucleus* infection in a young Blue Tang *(Paracanthurus hepatus)*. Note formation beginning behind the eyes, color, and weight loss.

Figure 31

Hexamita or *Spironucleus* parasites in the intestine (200x magnification).



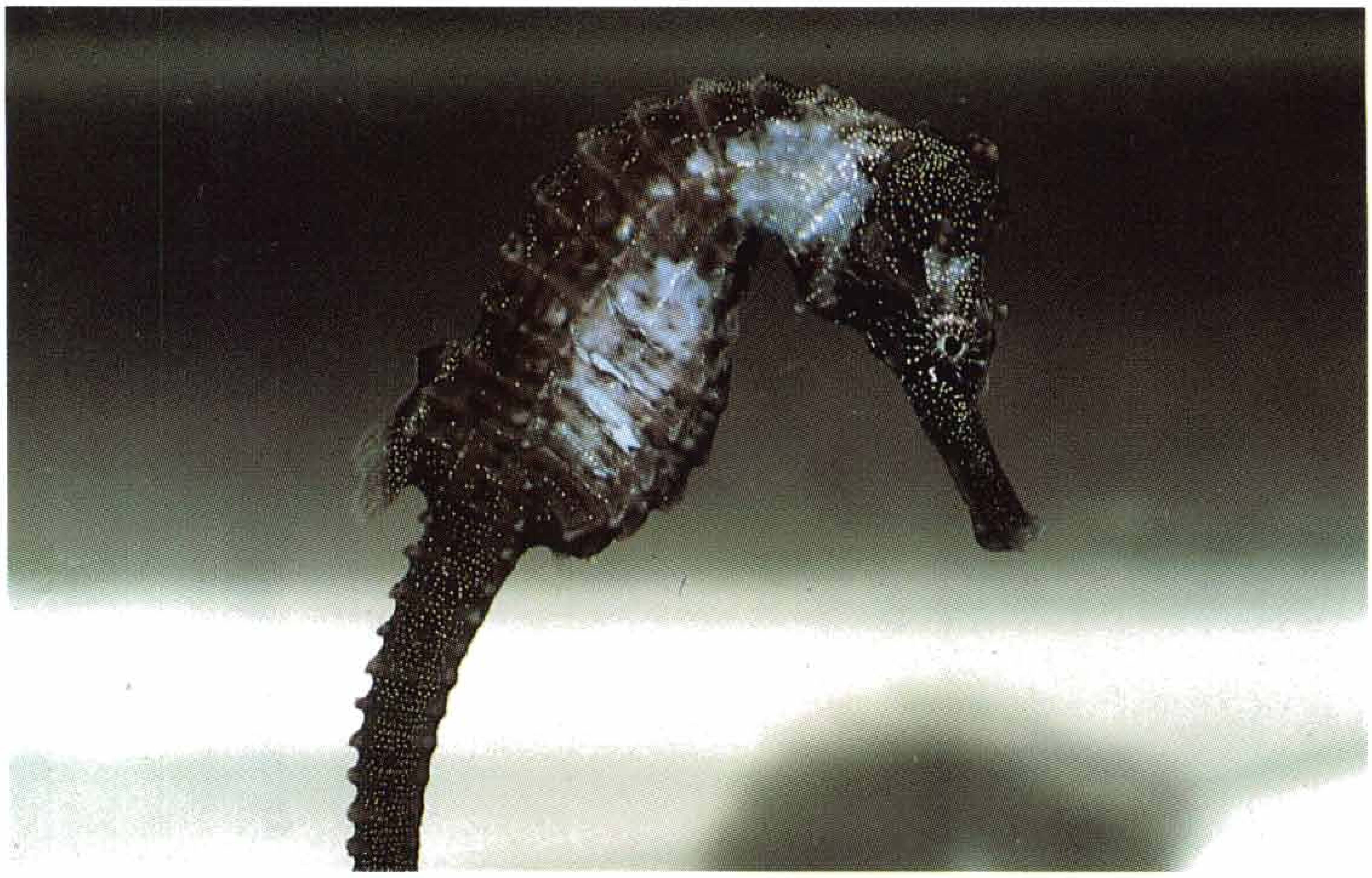


Figure 32

A Yellow Seahorse *(Hippocampus kuda)* with parasitic skin infection, caused by flagellates *(Costia type)*. Recognizable by pale skin patches with secondary bacterial infection.

Other external flagellated parasites

Different kinds of flagellates occur on the skin and/or gills of tropical marine fish. *Cryptobia* are frequently found on imported, harshly treated fish. This parasite corresponds to *Cryptobia branchialis* in freshwater fish (Burreson & Sypek, 1981)[4], (Lom 1980)[5].

Small flagellates are found on some freshly imported marine fish. These flagellates are similar to the bean-shaped parasites *Costia sp.* or *Ichthyobodo necatrix* found in freshwater fish. However, not much information has been published about these (*Figure 32*). In general, infected fish exhibit the following symptoms: dark coloration, increased mucus buildup, occasional turbidity of the skin, loss of scales, difficult or accelerated respiration, reduced appetite, and weight loss. Secondary bacterial infections develop in the more advanced stages. These lead to pale and/or red skin patches as well as skin and fin rot. With the help of skin and fin smears, these small mobile parasites (size approx. 5-12 µ) can be easily detected under the microscope (200x to 300x magnification). Strongly attached parasites, e.g. *Cryptobia,* are more often observed on fin tissue.

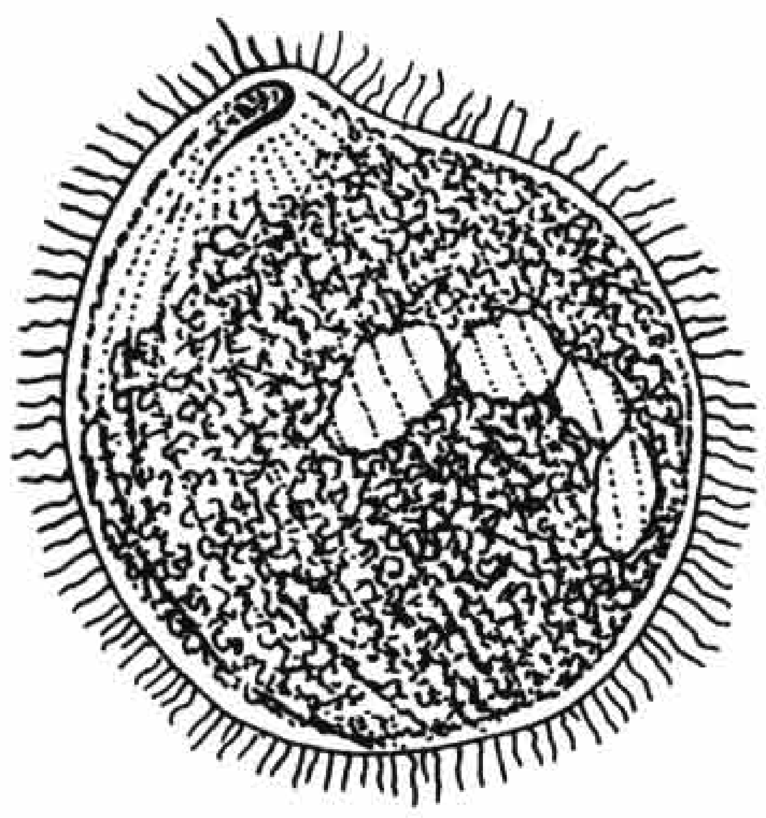
[4] Burreson, E. & Sypek, J. (1981): *Cryptobia sp.* from the gills of marine fishes in the Chesapeake Bay. Journal of Fish Diseases 4 (6): 519-522.

[5] Lom, J. (1980): *Cryptobia branchialis* Nie from fish gills: ultrastructural evidence of ectocommensal function. Journal of Fish Diseases 3 (5): 267-287.

Treatment

Treatment with formaldehyde/malachite green or formaldehyde/copper sulfate produces good results. At the same time, fish may be placed in freshwater baths or given effective antibacterial agents such as nifurpirinol or furaltadone.

White spot disease or *Cryptocaryon irritans* (also called: Saltwater Ich)



Cryptocaryon

Cryptocaryon irritans or white spot disease is probably the most frequently occurring disease in tropical marine fish. This also applies to its counterpart in tropical freshwater fish, *Ichthyophthirius multifiliis*.[6] The disease is caused by ciliates.

Fortunately, this disease can be recognized by the typical white spots on skin, fins and gills. At first, only a few white spots are scattered over the body. These later divide and attack the entire fish (*Figures 33-36*).

This disease usually develops after drastic, temporary changes in water environment, such as over-heating or cooling caused by defective water heaters or electric current loss. Infection may also be attributed to rapid cooling or temperature fluctuations in rooms where aquaria are located (typical for spring or autumn) or high concentrations of ammonia, nitrite or nitrate, very low pH or degree of acidity. In other words, many factors can contribute to the reduced resistance of the fish which makes them more susceptible to parasites such as *Cryptocaryon irritans* which are almost always present in aquarium water.

Besides typical white spots, fish sometimes exhibit increased mucus production, eye cloudiness, frayed fins, secondary bacterial infections with skin and fin rot, and red or pale patches (*Figures 34, 36*). As parasites usually infect gills first, fish also have breathing problems.

Fish try to relieve irritation by rubbing their fins against corals or the bottom of the aquarium. At the same time, they also tend to stay at the water surface or close to filter outflow openings.

At 100x microscopic magnification, large, dark ball- or cone-shaped parasites (350-450 µm in diameter) can easily be identified on skin and fin smears (*Figures 37-39*).

The white spots caused by adult *Cryptocaryon irritans* are known as *trophonts*. In the mature stage, these fall from fish and encapsulate themselves. These encapsulated spots or *tomonts* divide into daughter cells (approximately 200), which in turn develop into small, ciliated organisms (size 30 to 50 µ), *tomites*, that swarm, looking for new hosts. They bore into the mucosa of the skin, fins and gills of host fish and mature into typical

[6] See also: Blasiola, G. (1976): A review of "white spot" *Cryptocaryon irritans*. Marine Aquarist Magazine, 7 (4): 5–14.

adult white spots. If they do not find hosts within 24 hours, they die. Primarily, treatment is aimed at killing tomites.

Treatment

You should determine first whether the water quality is sufficiently good. Otherwise, treatment will only worsen the situation. The combination of formaldehyde - malachite green or formaldehyde - copper sulfate has proven to be more effective than copper sulfate alone. WATCH OUT! It can harm your invertebrates!

Sufficient dosage and 8-10-day treatment periods are important to ensure that all *tomites* are killed. Daily freshwater baths are recommended as additional treatment for infected fish. Methylene blue can also be added to this water. The more quickly treatment is begun, the better the results will be.

If the disease is discovered too late, antibacterial agents must be administered simultaneously to combat secondary bacterial infections. Nifurpirinol, furaltadone, and Linco-Spectin® are effective preparations. Good results have also been achieved with quinine hydrochloride but invertebrates can be killed. Always be cautious!

Adding vitamin C to food (500 mg/100 g food) has a preventive effect and can help cure seawater ichthyo infections.

Some aquarists recommend quinacrine (Mepacrin®, Atabrin®), although the results are not convincing.

Figure 33

White spots, *Cryptocaryon irritans* on a *Acanthurus japonicus.*

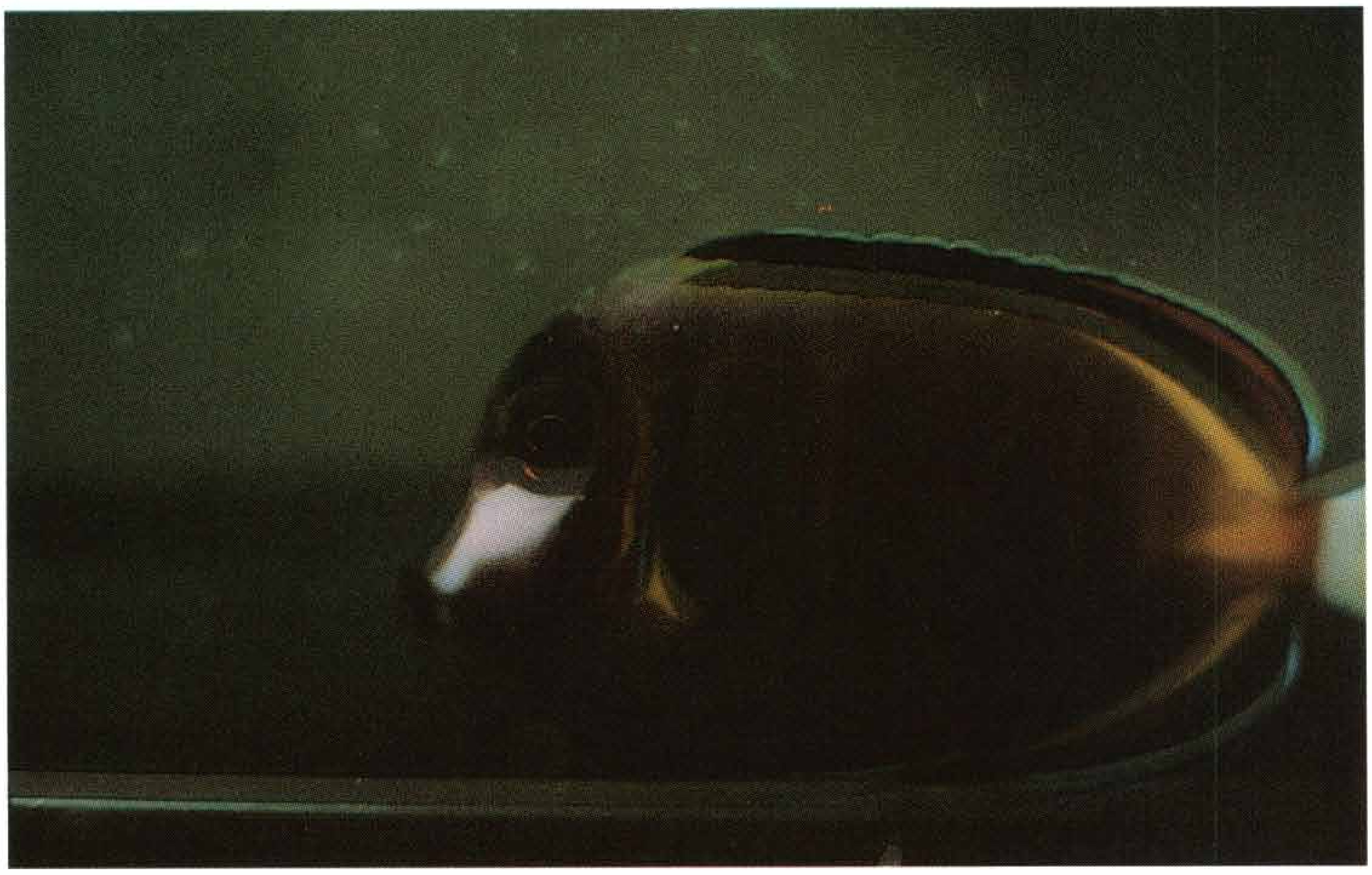


Figure 34

White spots, accompanied by skin irritation, increased mucus formation and cloudy eyes in another *Acanthurus japonicus.*

Figure 35

Larger number of white spots, *Cryptocaryon irritans*, clearly recognized on a Tomato Clown *(Amphiprion frenatus).*

Figure 36

Cryptocaryon irritans infection on a Moorish Idol *(Zanclus cornutus)*, with clearly recognizable white spots on the black bands, which are practically invisible on the pale yellow bands.

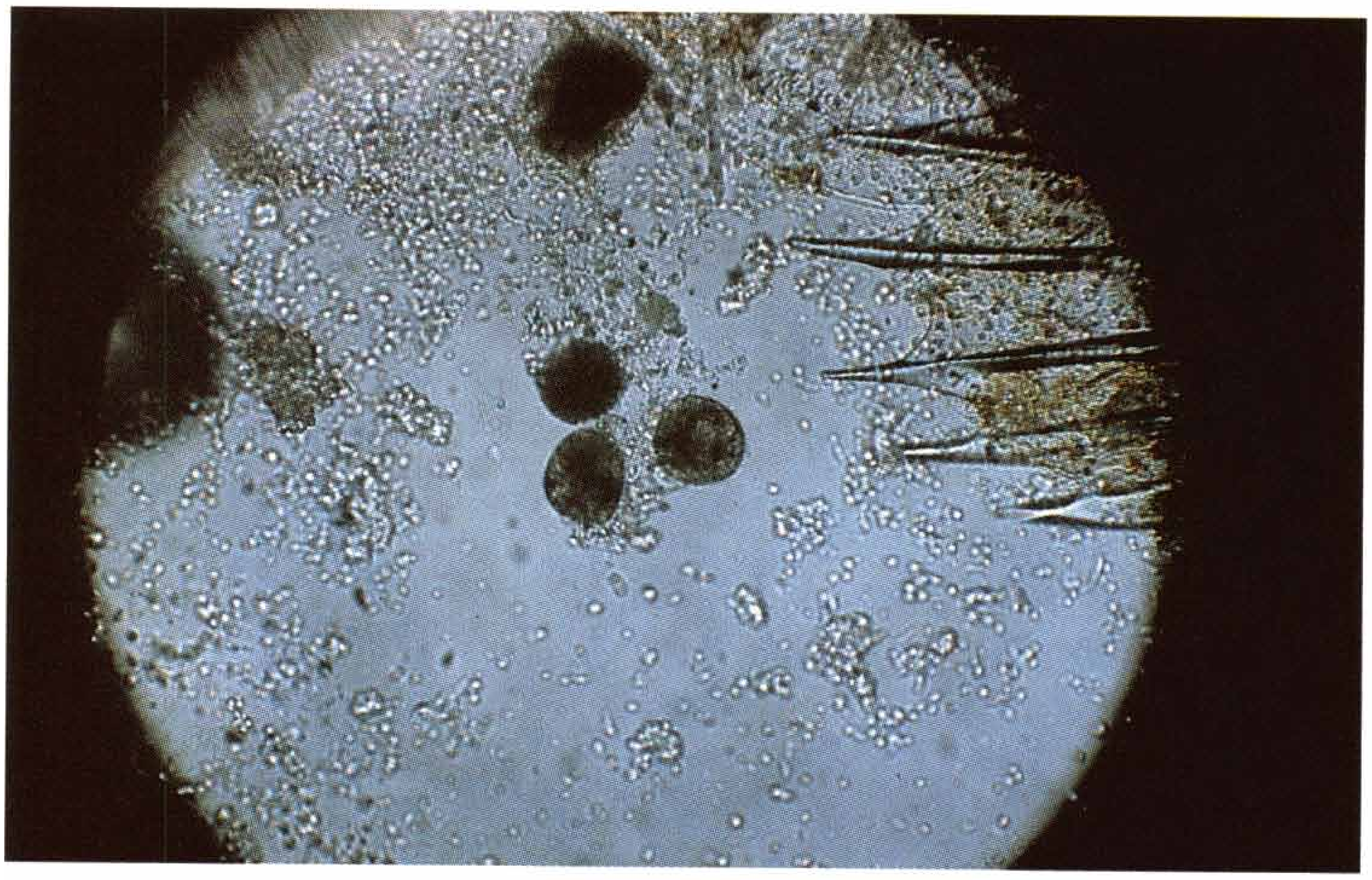


Figure 37

Dark, cone-shaped *Cryptocaryon* parasites at 100x magnification.

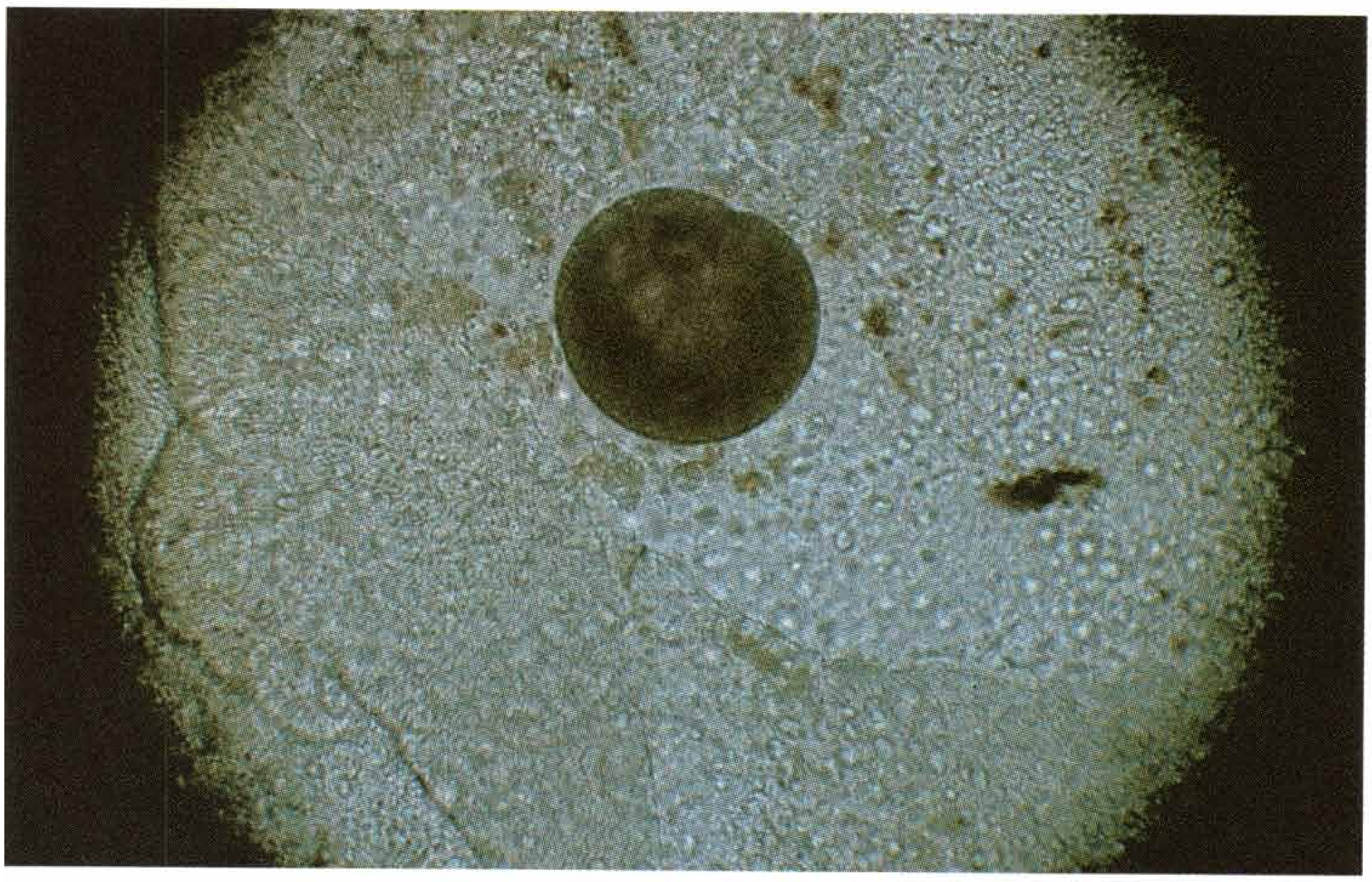
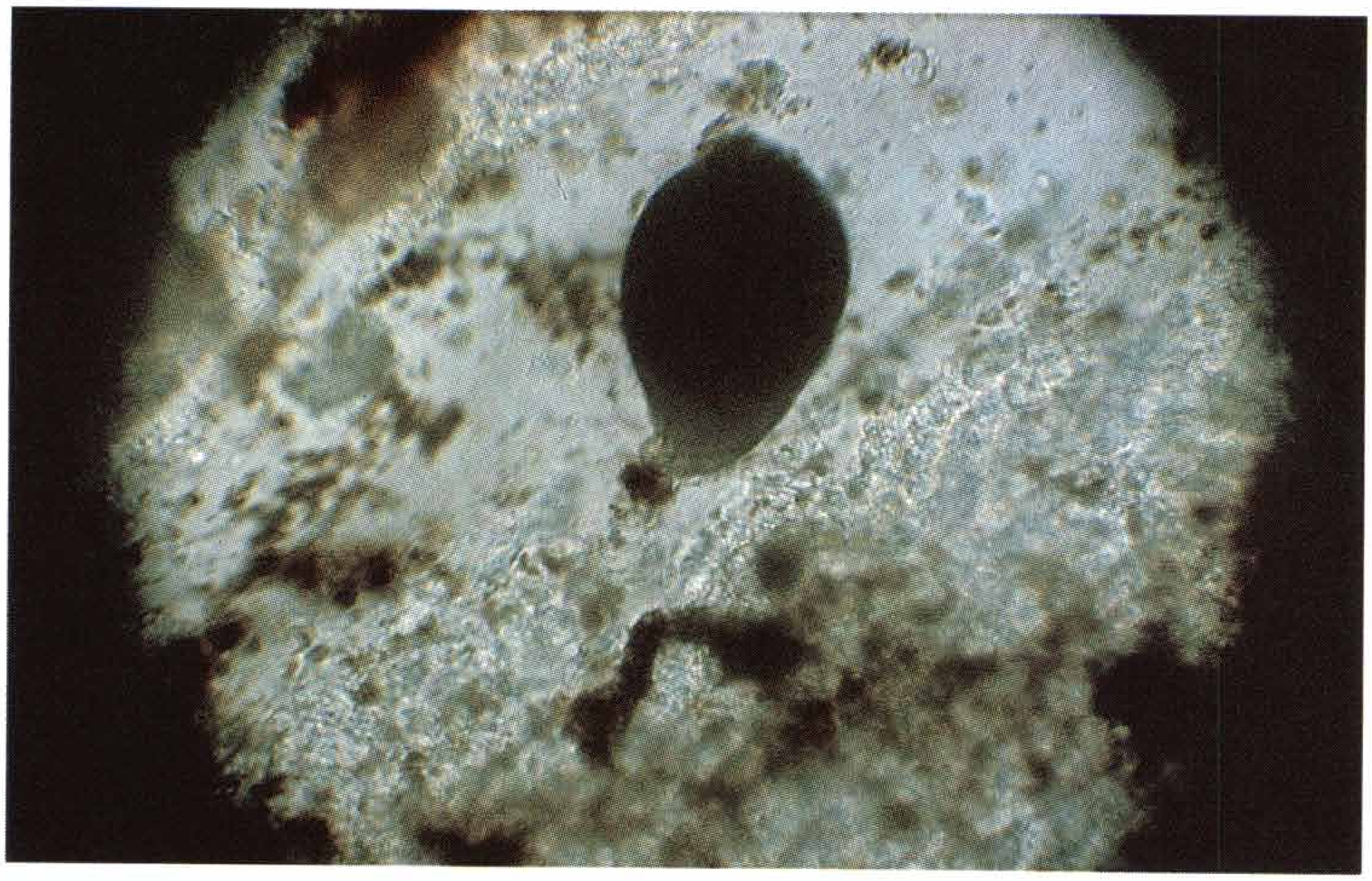


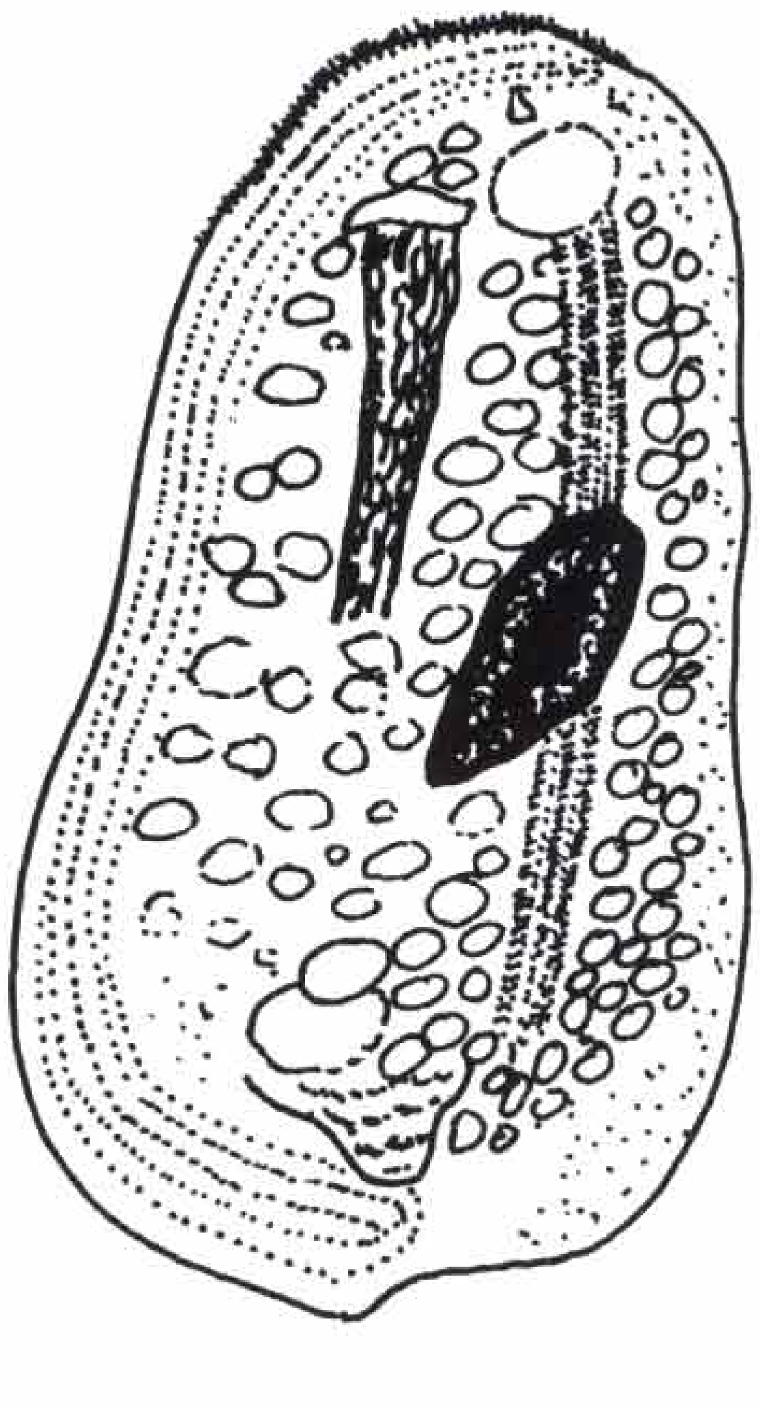
Figure 38

Typical dark cone-shaped "white spots" due to *Cryptocaryon irritans* with slightly transparent nucleus (220x magnification).

Figure 39

Pear-shaped *Cryptocaryon irritans* in motion (200x magnification).





Brooklynella hostilis

Brooklynella hostilis: Turbidity of the skin

Brooklynella hostilis is a frequently occurring disease in tropical marine fish. *Chilodonella sp* is its counterpart in freshwater fish.[7]

Typical symptoms are turbidity of the skin, sometimes accompanied by dark slimy layers hanging like strings, eye cloudiness, breathing difficulties with open gill covers (*Figures 40-44*). Infected fish become listless, lose their appetite, lie on the bottom of the aquarium or remain near the surface of the water, gasping with open mouths for air. At first, no symptoms can be observed. However, after a few days, the fish exhibit clear symptoms: weakness, breathing difficulties and strong turbidity of the skin. Some *Brooklynella hostilis* parasites are also found in healthy fish when they are suddenly stressed by poor environmental conditions, fights, or incomplete diet. Their defense mechanism is then weakened considerably and they become very susceptible to parasitic infection. Cell division of *Brooklynella* parasites occurs quickly. As a result, they can cause severe damage to fish. Severely infected fish exhibit secondary bacterial infections accompanied by red skin patches and wounds, skin and fin rot (*Figures 41, 42*). Typical hemorrhaging can be observed on the gills. Chances of survival are correspondingly poor.

At first, these parasites appear in the area around the gills, but then spread rapidly over the entire skin surface.

[7] See also: Lom, J. & Nigrelli, R. (1970): *Brooklynella hostilis* n.g.n. sp., a Pathogenic Cyrtophirine Ciliate in Marine Fish, Journal of Protozoology, 17 (2): 224–232. Blasiola, G. (1980): Disease Prevention and Control: *Brooklynella,* a protozoan parasite of marine fish... Freshwater and Marine Aquarium (FAMA) Magazine Vol. 3, No. 6.

Relatively large (50-80 µm) bean- or kidney-shaped ciliates are easily recognized in skin and gill smears (*Figures 45-48*). Typically, these parasites encircle tissue and attach firmly to it.

Treatment

Formaldehyde in combination with malachite green has been established as a positive treatment.
Quinacrine sometimes yields positive results, but may be toxic to weaker fish. Copper sulfate should not be used due to its limited efficacy against *Brooklynella*. As well as treating the aquarium, one should treat the strongest fish in freshwater baths in order to kill as many parasites as possible.
To prevent or combat secondary bacterial infections, antibacterial agents such as nifurpirinol, neomycin, sulfonamide or Linco-Spectin® should also be administered. The earlier the treatment is started, the better results will be.

Figure 40

Brooklynella infection in a Domino Damsel *(Dascyllus trimaculatus)* accompanied by turbidity of the skin, scale loss, color loss and cloudy eyes.

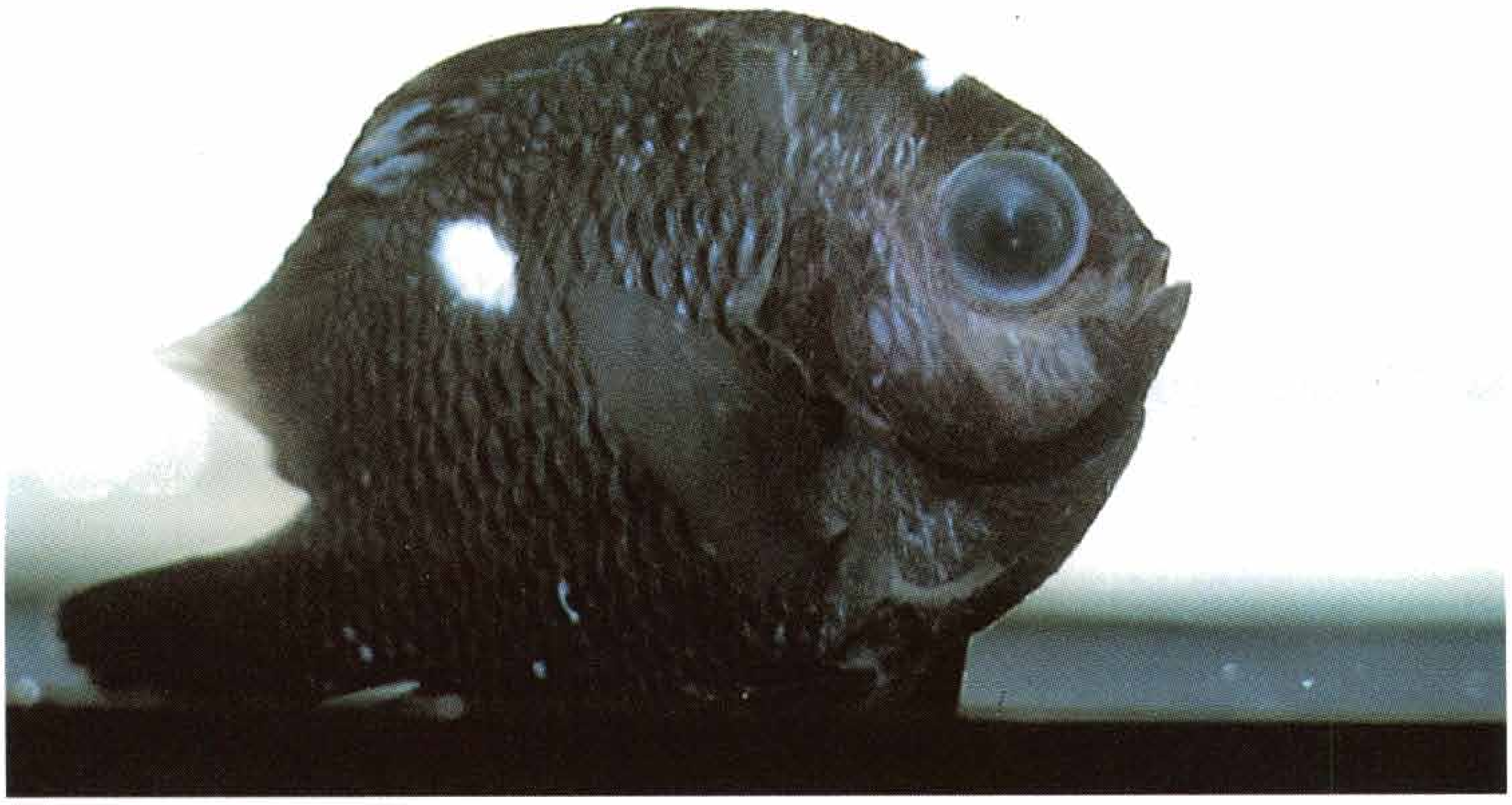


Figure 41

Brooklynella infection accompanied by skin cloudiness, red wounds as well as fin rot (bacterial secondary infection) in a Domino Damsel *(Dascyllus trimaculatus)*.

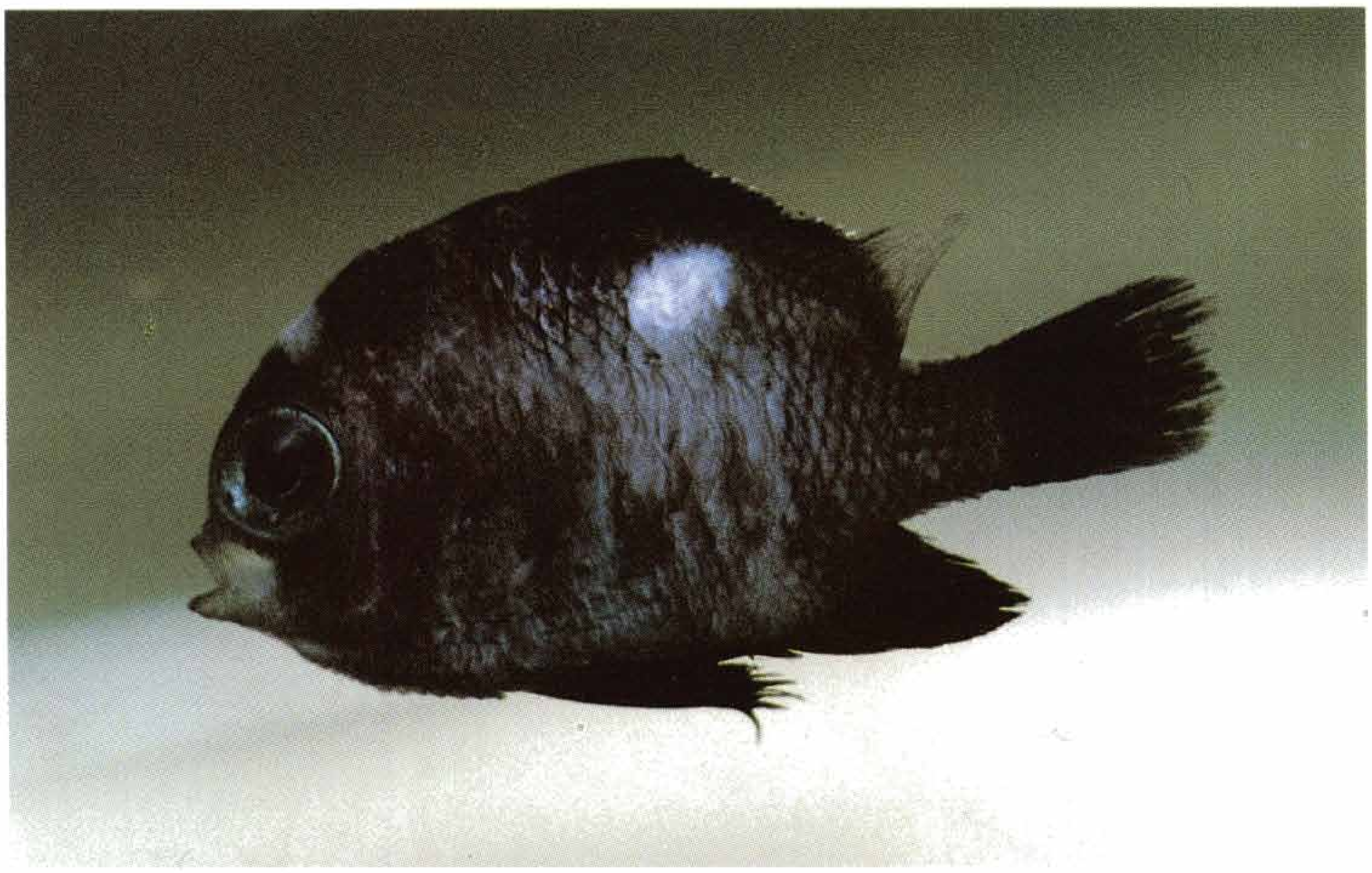


Figure 42

Severe, advanced *Brooklynella* infection with bacterial secondary infection (fin rot, wounds) in a dying Domino Damsel *(Dascyllus trimaculatus)*.

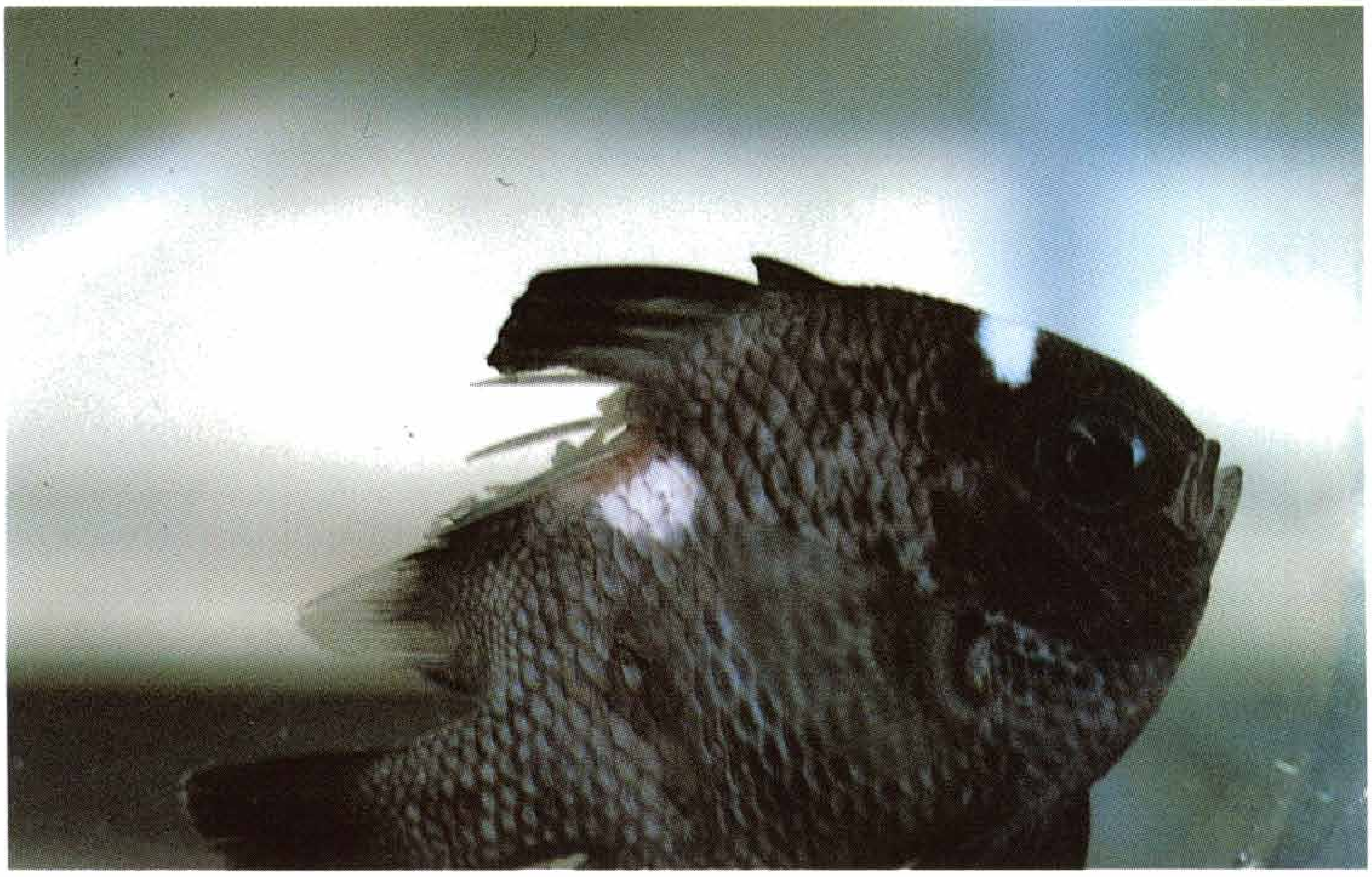


Figure 43

Spotfin Lionfish *(Pterois antennata)* with weight loss, pale color loss and turbidity of the skin, caused by a *Brooklynella* infection.

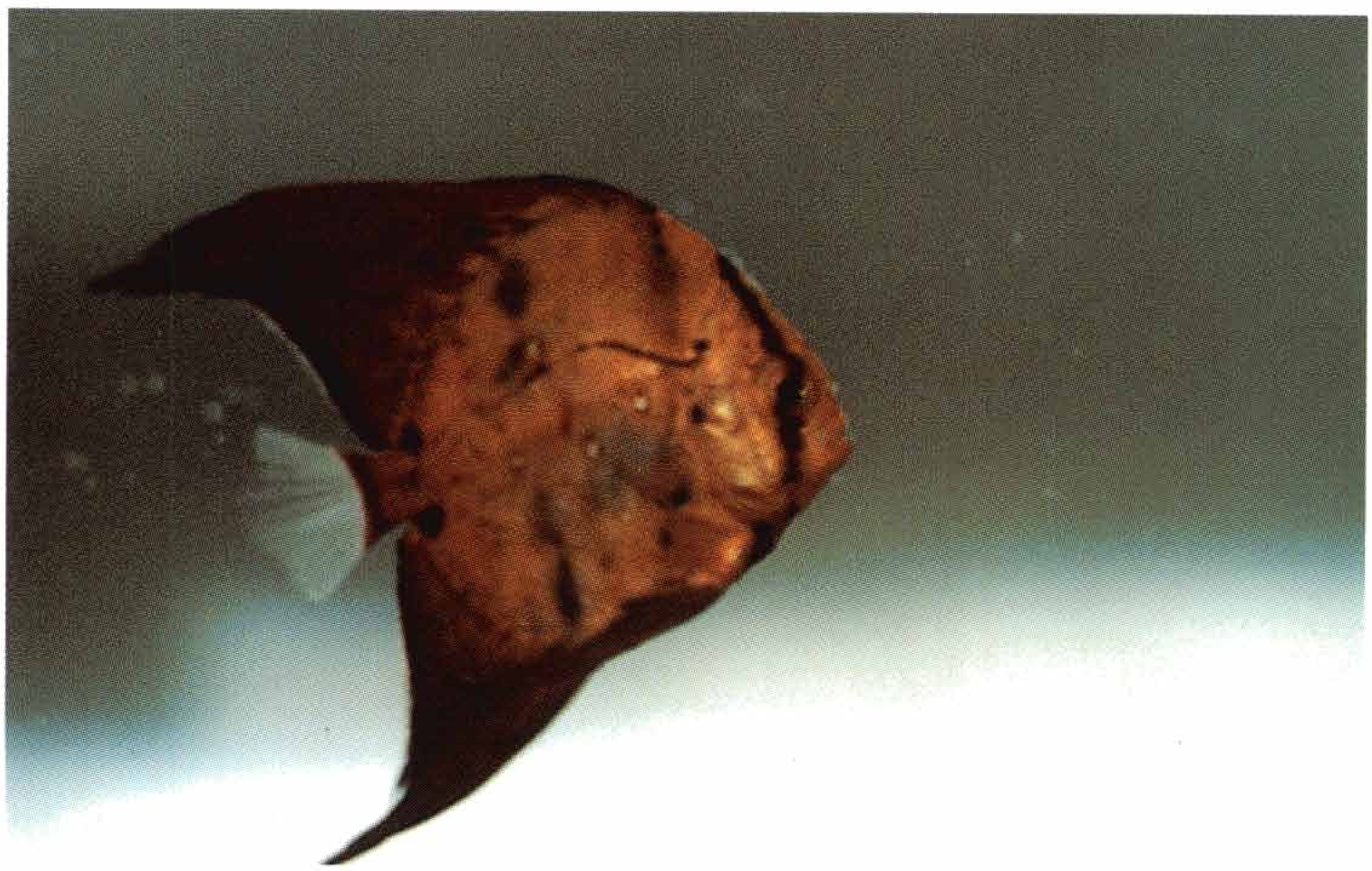


Figure 44

Common Batfish *(Platax orbicularis)* with faintly visible turbidity of the skin and weight loss, caused by *Brooklynella* infection.

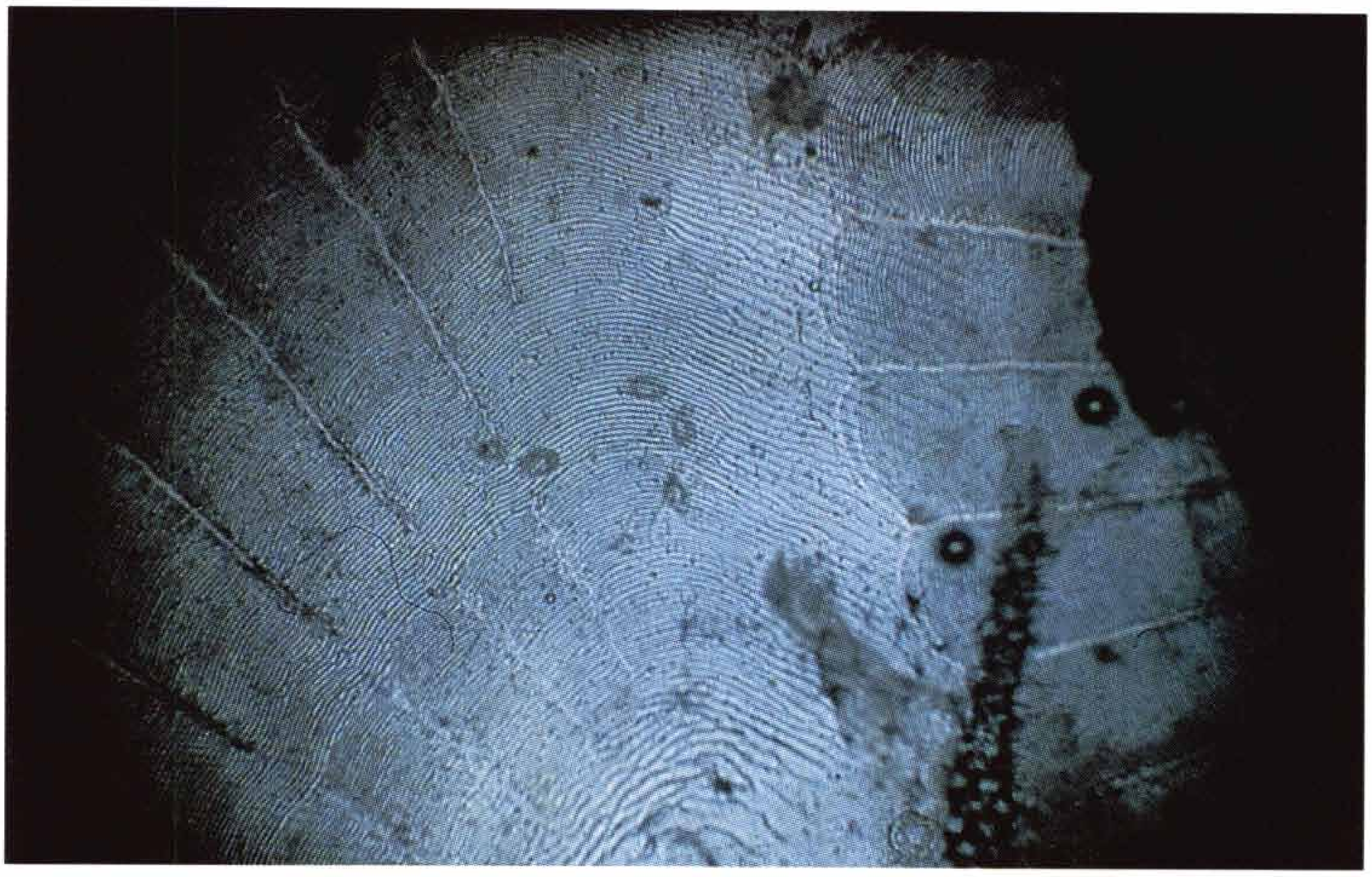


Figure 45

Individual *Brooklynella hostilis* on the scales of a skin smear (100x magnification).

Figure 46

Numerous *Brooklynella* parasites on the scale edges (200 x magnification).

Figure 47

Two *Brooklynella hostilis* parasites with their typical oval-shape (200 x magnification).

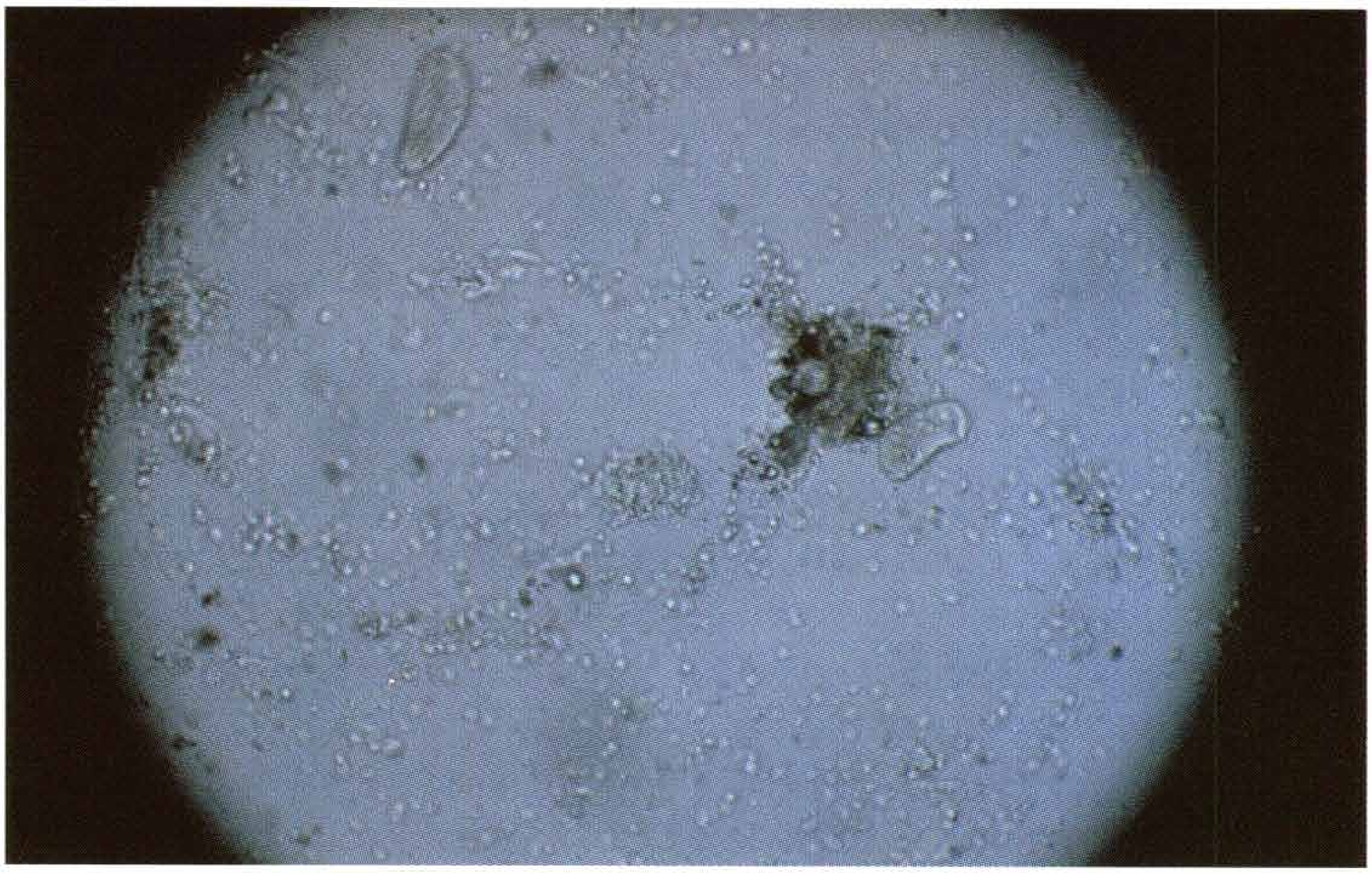
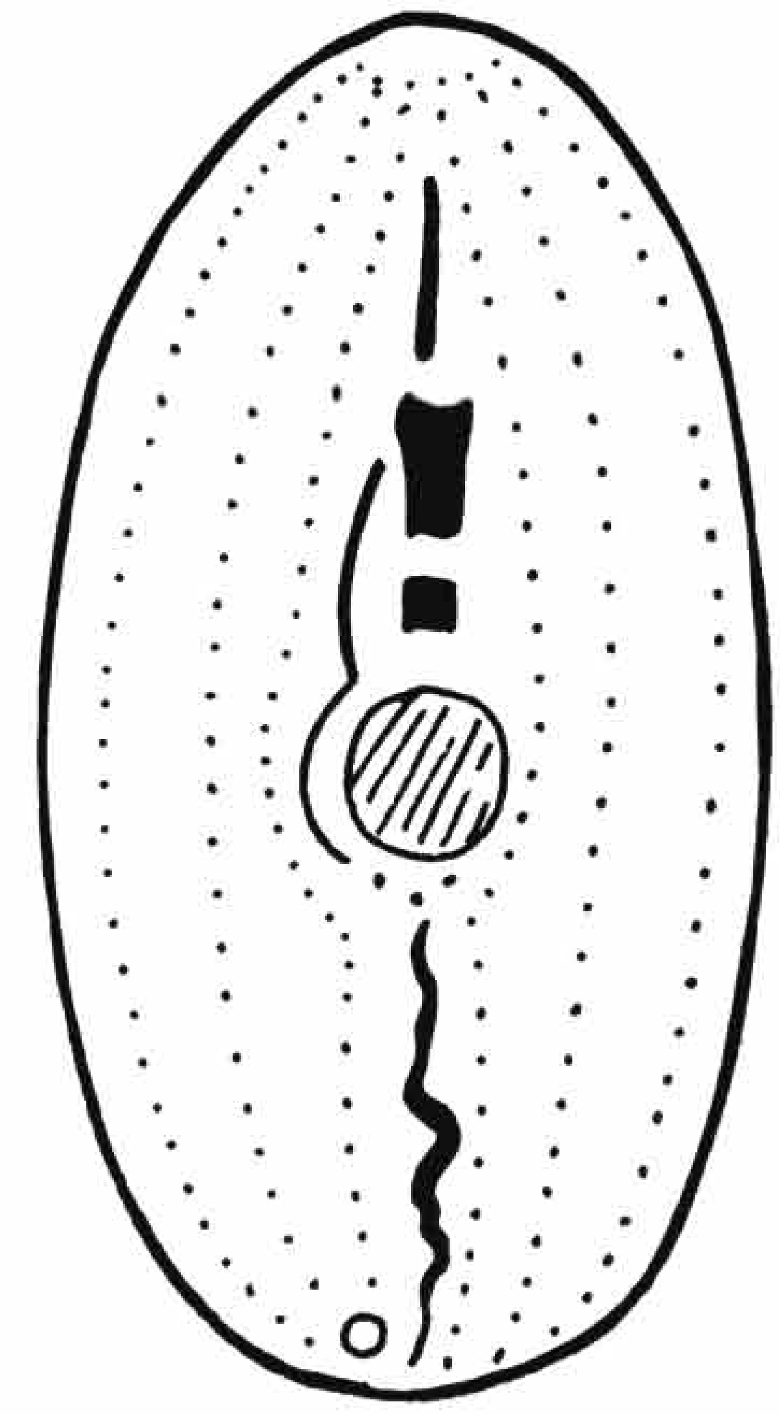


Figure 48

Parasite, *Brooklynella hostilis*, on the end of a gill filament (200 x magnification).

Uronema marinum



Uronema marinum

Uronema marinum is the counterpart to *Tetrahymena pyriformis* in fresh-water fish.[8]

These ciliated parasites are frequently found in weakened fish, especially in freshly imported fish, transported under very poor conditions. This infection can be disastrous for already weak fish since cure is practically impossible.

Typical symptoms are ulcer-like wounds or bloody sites which at first suggest bacterial infections. Thus, this disease is often incorrectly diagnosed or treated with antibacterial agents.

In the initial stage of the disease, increased mucus formation may develop on scales. Fish scrap themselves on the bottom of aquaria and breathe heavily. In more advanced stages, pale or red, bloody sites are observed. These develop into large wounds in the end stages. By this point, cure is rarely possible (*Figures 49-55*).

Uronema marinum parasites occur in seawater and seem to live on dead tissue and bacteria; of course, these so-called 'cleaners' are often found on dead fish. Marine fish, transported for 24 to 48 hours in water which has low pH, too much ammonia and organic waste, and low concentration of dissolved oxygen apparently offer the ideal nutritive media for these parasites. Under these conditions, they feed on damaged tissue and multiply quickly (cell division), also infecting healthy tissue. They insert deeply into underlying muscular tissue, causing irreparable injury. Parasites are also found in gills. As a result, infected fish suffer from respiration problems. Severe infection of the gills is often sufficient to suffocate fish due to insufficient gas exchange or lack of oxygen intake, while skin shows no abnormal signs. This can also occur in *Brooklynella* infections but is not typical.

In addition to the pathological indications, fish behave abnormally, scrub themselves on the bottom of the aquarium, clamp fins, lie on the bottom, swim around at the surface and gasp for air.

Secondary bacterial infections result from damage caused by this activity. Numerous small oval-shaped, fast-moving parasites can be seen in skin and fin smears. These parasites swarm, boring their way into tissue. *Uronema marinum* parasites are practically the same size (35-50 µ) as *Tetrahymena* in freshwater fish (*Figures 56, 67*).

[8] See also: Cheung, P., Nigrelli, R. and Ruggieri, G. (1980): Studies on the morphology of *Uronema marinum* (Ciliatea: URONEMATIDAE) with a description of the histopathology of the infection in marine fish. Journal of Fish Diseases 3, 295–303.
Bassleer, G. (1983): Disease Prevention and Control. *Uronema marinum*, a new and common parasite on tropical marine fish. Freshwater and Marine Aquarium (FAMA) Magazine, Vol.6, No. 12.

Treatment

Treatment should primarily be aimed at saving non-infected fish.
Formaldehyde — Malachite green or malachite green alone are effective. Quinacrine (Atabrin®, Mepacrin®) is also an effective treatment. Short baths with highly concentrated methylene blue can also be helpful. Freshwater baths can also be used.
Combining different methods sometimes yields excellent results. For example, consider an aquarium treated with formaldehyde-malachite green. The fish are placed in a freshwater bath for 3 to 10 minutes over five days and subsequently placed in a seawater bath with highly concentrated methylene blue solution. The fish are then returned to the disinfected aquarium. Sometimes, antibacterial agents also need to be used. These can be added to the aquarium or into the methylene blue bath. Furaltadone or nifurpirinol is also recommended.

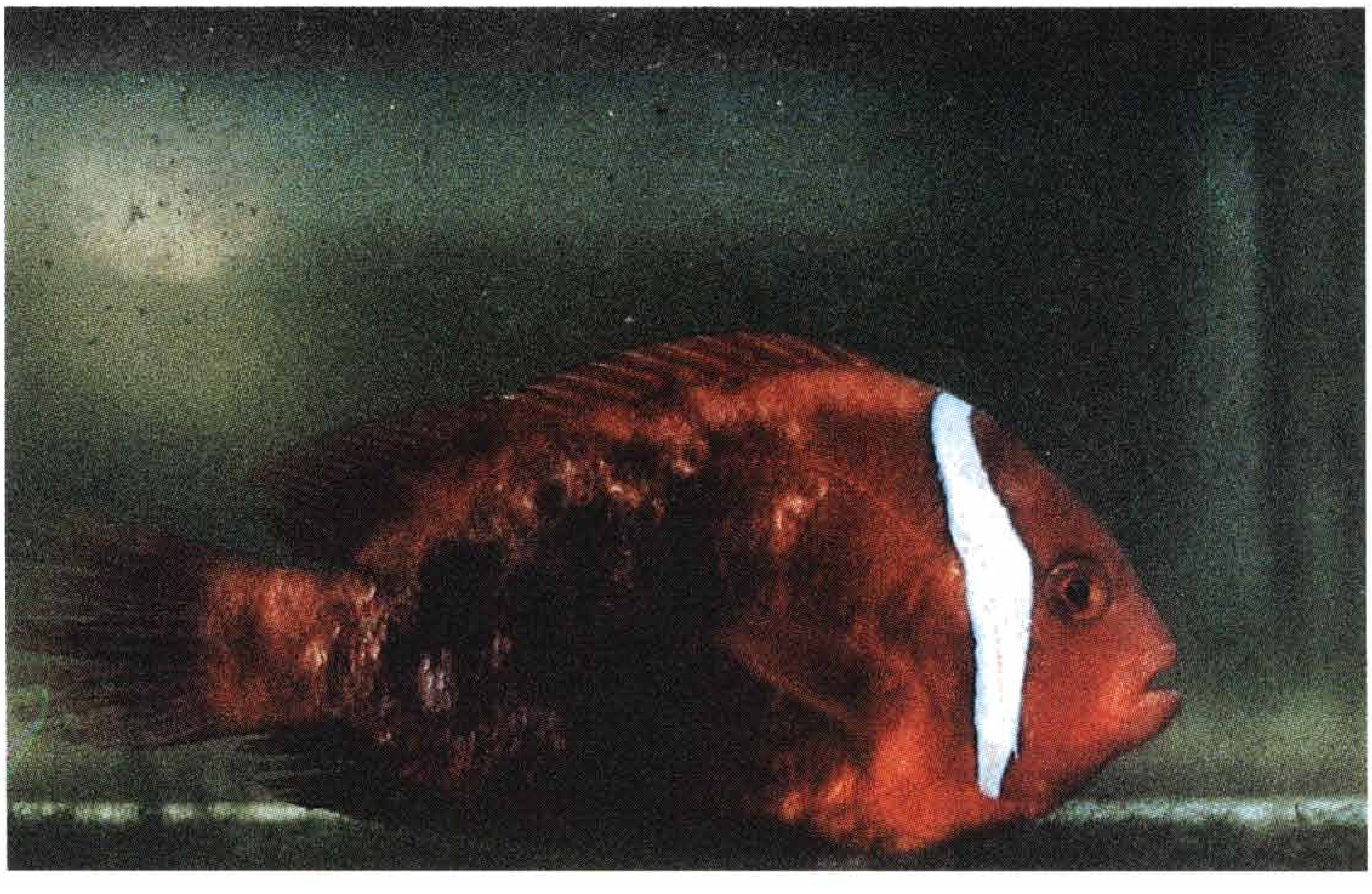


Figure 49

Tomato Clown *(Amphiprion frenatus)* with pale patches, scale loss, beginning tail rot, caused by parasitic infection, *Uronema marinum.*

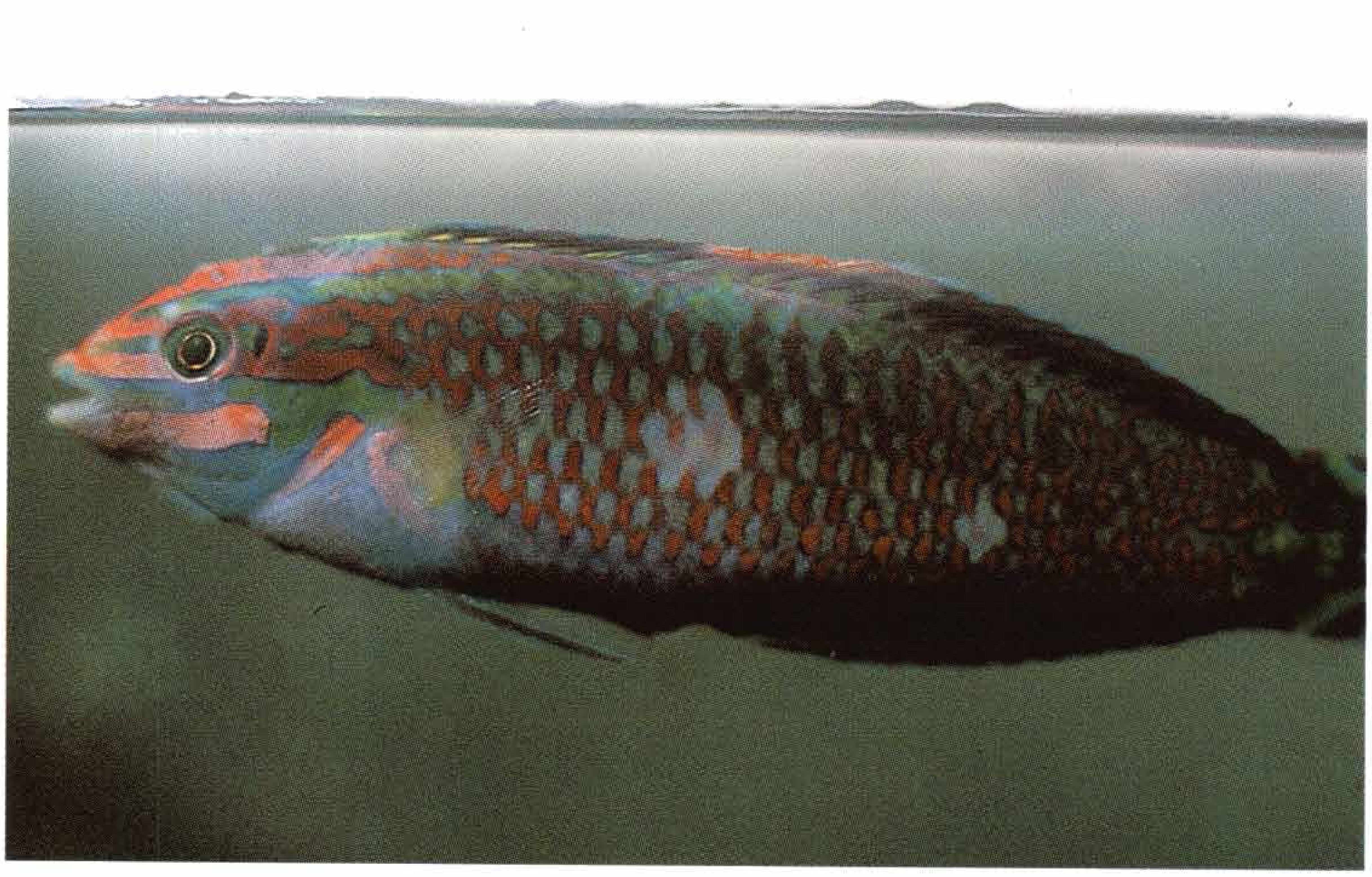


Figure 50

Christmas Lip fish *(Halichoerus biocellatus)* with pale patches and turbidity of the skin caused by *Uronema* infection.

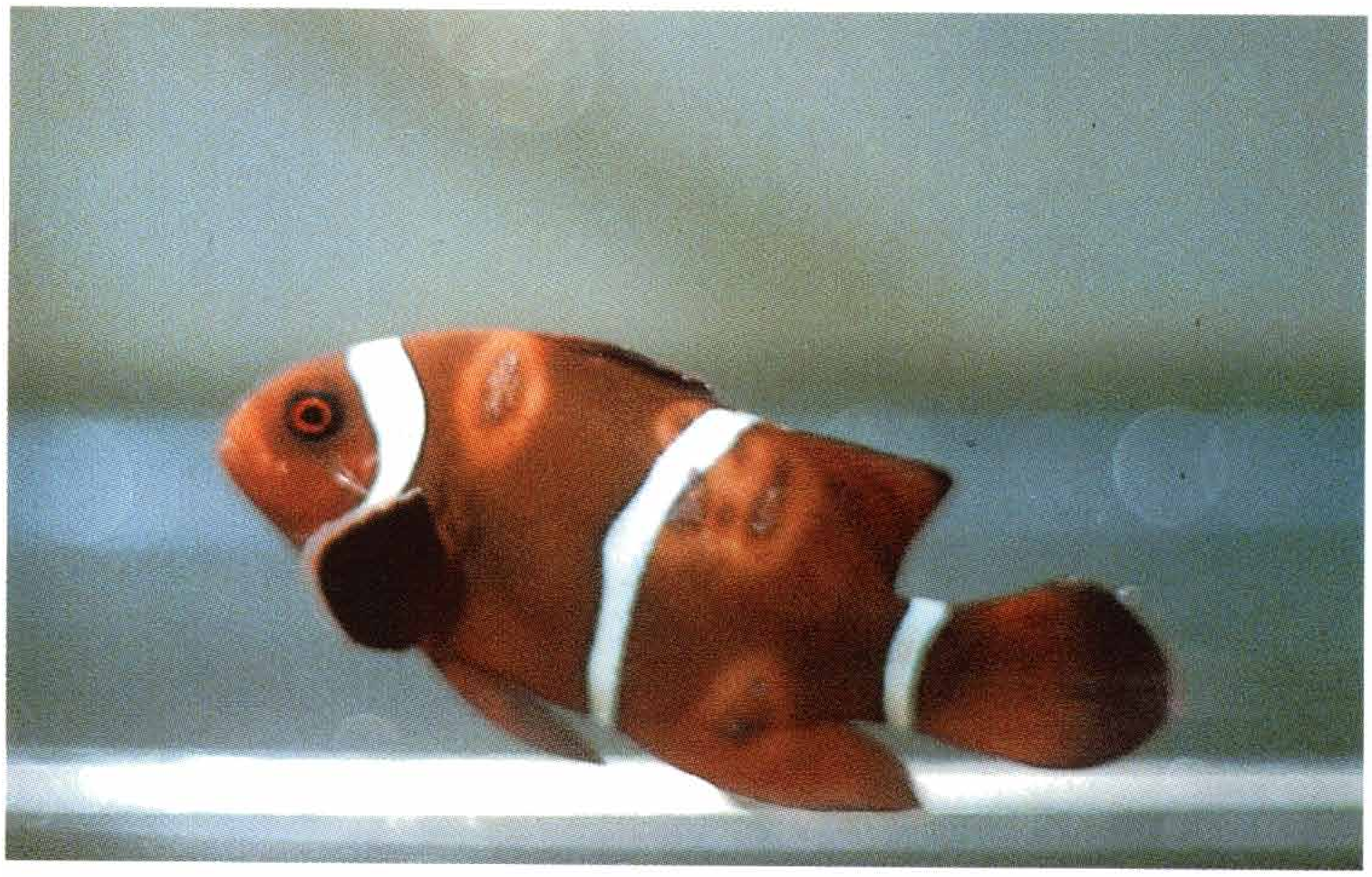


Figure 51

A Clownfish *(Premnas biaculeatus)* with pale skin wounds at different sites, caused by *Uronema* infection.

Figure 52

A Wimplefish *(Heniochus acuminatus)* with pale dorsal patches and reddish ventral skin, both caused by *Uronema* infection.

Figure 53

A Lemonpeel *(Centropyge flavissimus)* with bloody patches, covered over skin and dorsal fins, caused by a *Uronema* infection.

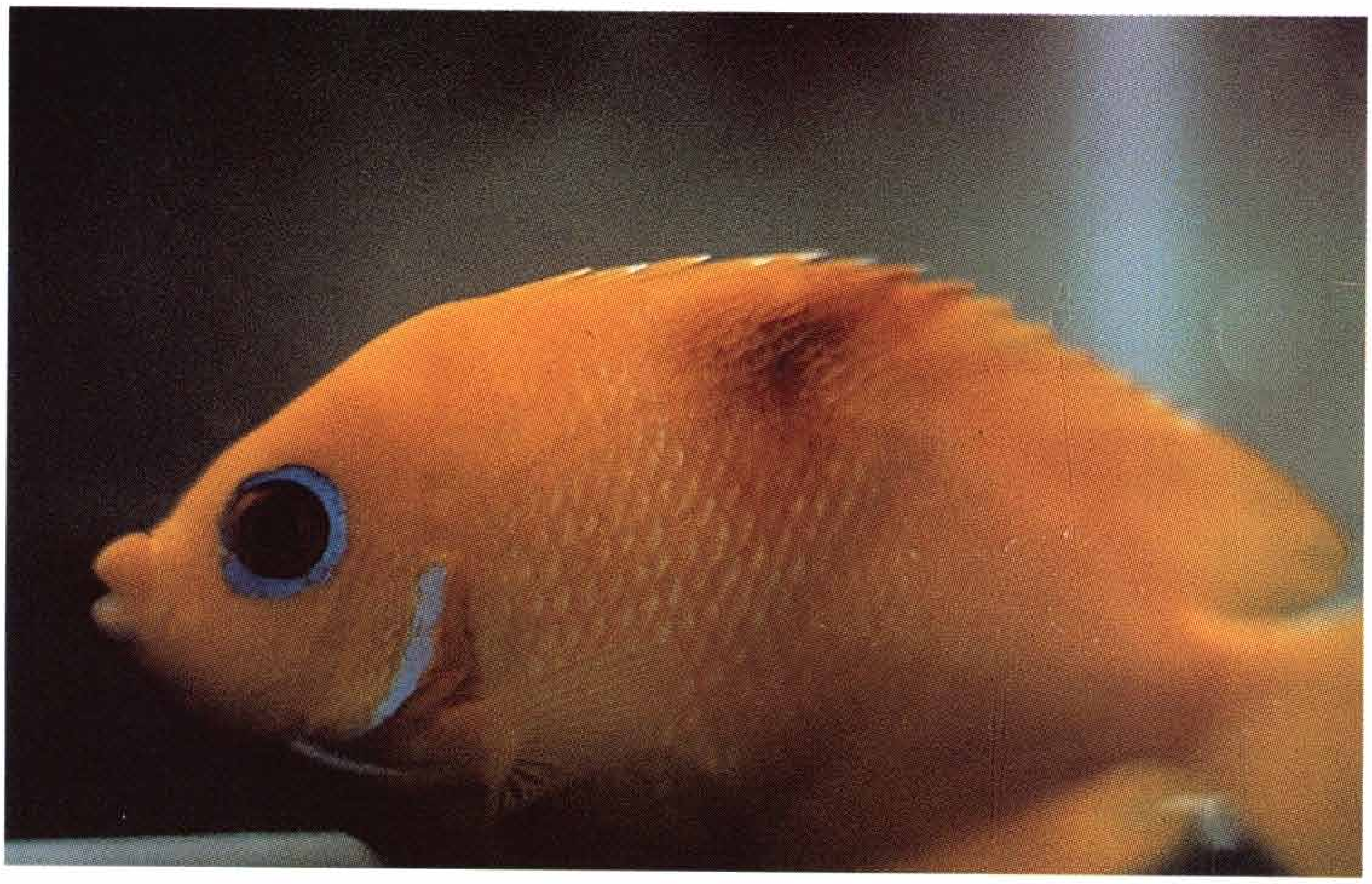


Figure 54

A Vagabund Butterflyfish *(Chaetodon vagabundus)* with bloody wound, caused by a *Uronema* infection.

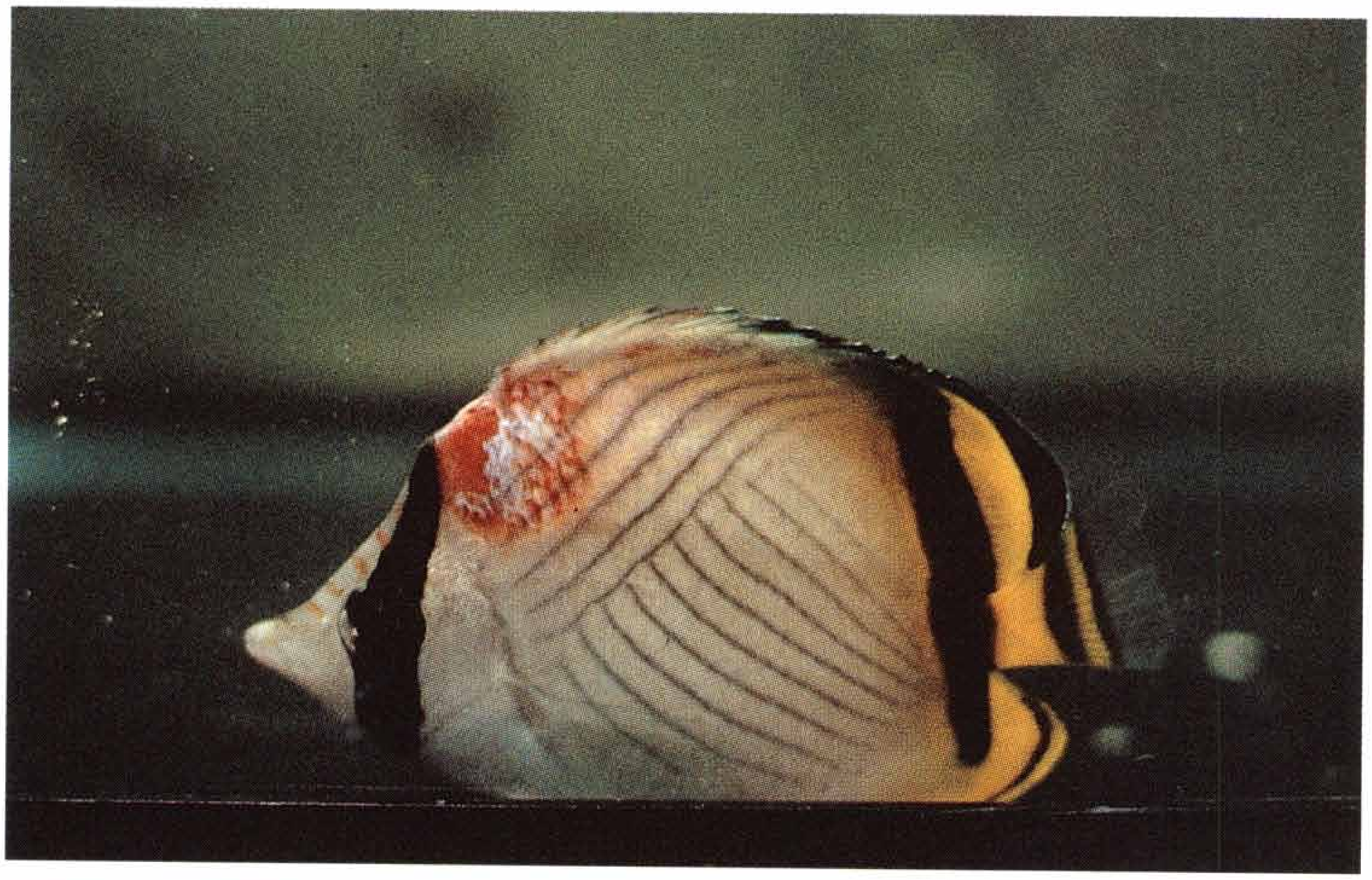
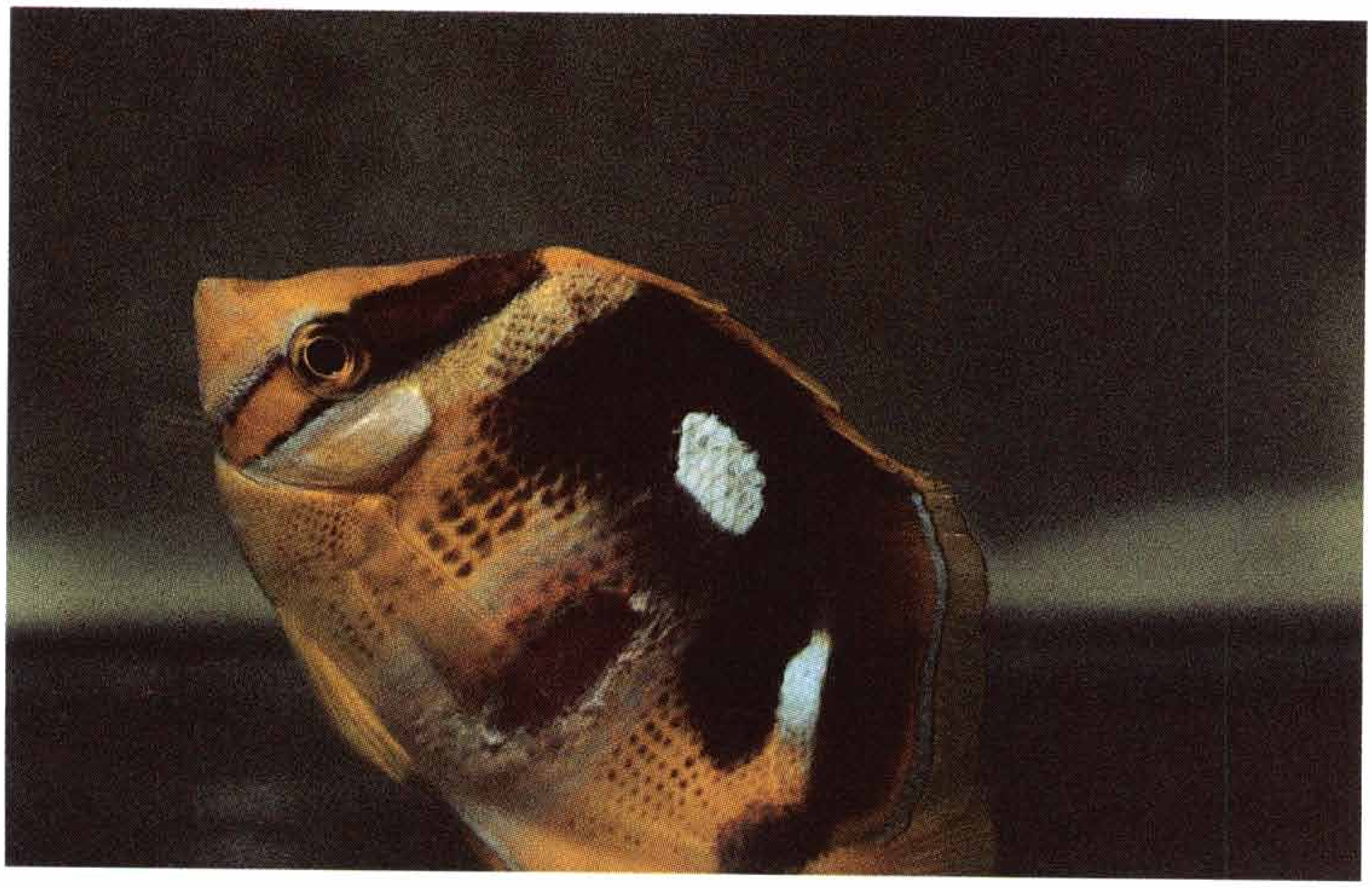


Figure 55

A Treadfin Butterflyfish *(Chaetodon auriga)* with bloody patch and raised scales, caused by a *Uronema* infection.



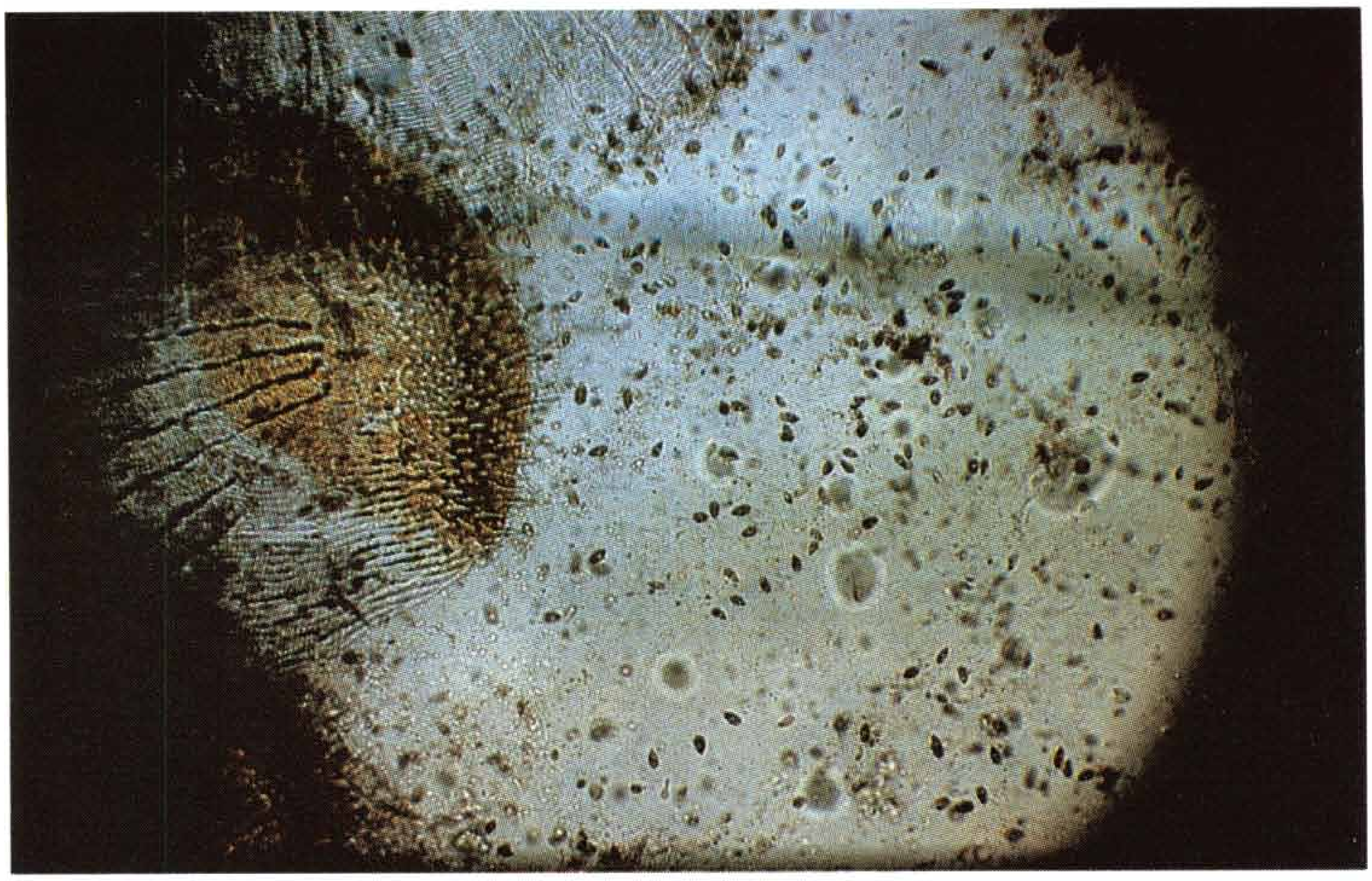


Figure 56

Skin smear with many *Uronema marinum* parasites (100x magnification).

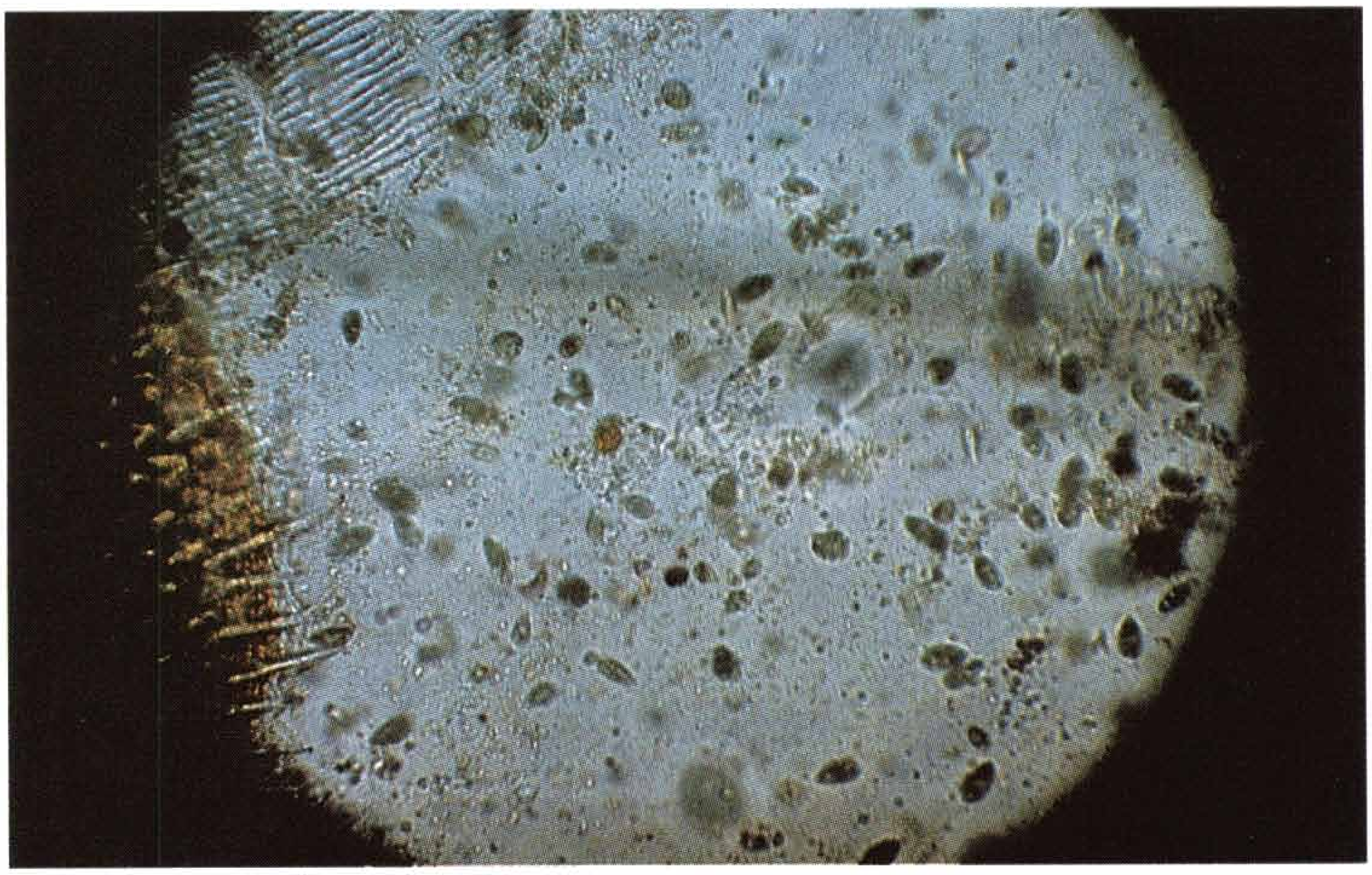


Figure 57

Many *Uronema marinum* parasites with their typical, sharply defined oval shape (200x magnification).

Trichodina sp.

Trichodina

Occasionally, *Trichodina* are found on tropical marine fish kept or imported under extremely poor conditions. This parasite is known by the same name in freshwater fish. However, they primarily attack the gills of marine fish and the skin of freshwater fish. In advanced infections, parasites are also found on the skin. Small numbers are also found in healthy fish when they are exposed to considerable stress (e.g. poor transportation conditions) and thus weakened, making them susceptible to parasitic infestation. Large quantities of organic waste, excessively low temperatures, very low pH values, excessive ammonia contents, and low oxygen content all facilitate infection from these parasites.

Typical symptoms are breathing difficulty with opened gill cover, skin damage accompanied by scale loss and occasionally red, bloody patches. In addition, the fish may clamp fins, exhibit irregular swimming behavior and scrape themselves against the bottom of aquaria or corals. Fish usually die from the destruction of gill cells, which prevents breathing and leads to suffocation.

The typical rapidly moving plate-shaped parasites can be easily detected on gill and skin smears. These can be identified at 100x to 200x microscopic magnification.

Treatment

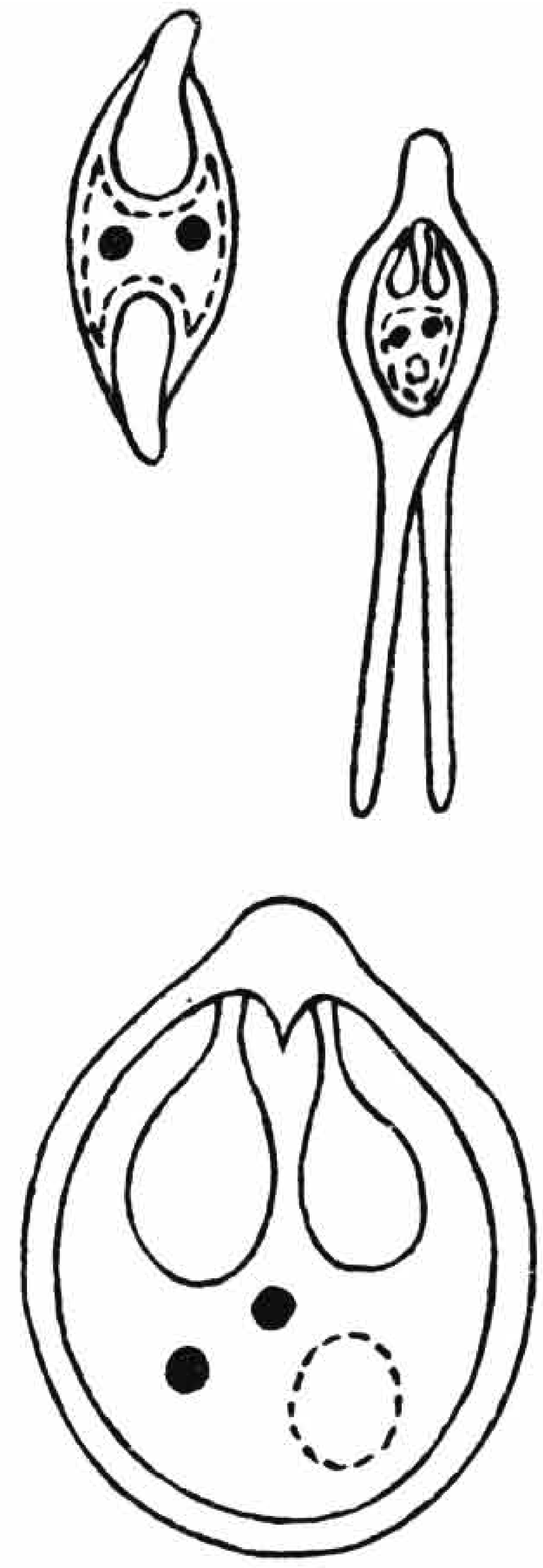
Formaldehyde — malachite green, and sometimes copper sulfate are sufficient to combat parasites if aquarium conditions are also improved. Antibacterial agents may be necessary to prevent or cure secondary bacterial infections.

Sporozoans

These parasites are not often found in tropical marine fish. They are found in internal organs or on skin, fins and gills in the form of cones, such as *Glugea heraldi*.[9]

Symptoms are weight loss and deformities as well as abnormal behavior. *Glugea heraldi* particularly infect seahorses. This sporozoan infection causes typical symptoms such as white nodules or deposits in the skin of hosts. However, this seldom occurs.

In the early stages, sporozoan infections are easily confused with those from *Cryptocaryon*, and in very advanced stages with *Lymphocystis*. By taking samples of infected tissue or organs, these tiny parasites can be detected under the microscope (300x to 500x).



Sporozoan

Treatment

There is no effective treatment for this disease. Prevention is always the best cure which is especially true with respect to this disease. Mostly, these parasites are transmitted to fish via infected fish or infected food.

[9] See also: Blasiola, G. (1979): *Glugea heraldi* n. sp. from the Seahorse. Journal of Fish Diseases 2, p. 439-450.

5.2 Worm infections

Worm infections, especially those caused by digenetic *Trematodes* or *Metacercaria* and *Nematodes* are found in 70 to 85% of the marine fish examined. This is a normal, frequently occurring 'natural' phenomenon in fish, which, like practically all marine fish, live freely in the wild and so are easily exposed to worm infections. In many cases, they can live with worm infestation without any serious problems. However, in cases of captivity, transportation, stress, weakness and exhaustion, worm infections can have severe consequences. In the right environment and when fed and cared for properly, fish can live with worm parasites. In these cases, no treatment is required.

Skin and gill worms (monogenetic *Trematodes*) occur only occasionally, while, digenetic *Trematodes* i.e. *Metacercaria* are often found inside tropical fish. *Nematodes* (round worms) occur mostly in the intestines as well as *Cestodes* (tape worms) and *Acanthocephalan* (spiny-headed worms).

Marine fish imported from Hawaii sometimes have infections caused by small whirl worms known as *Turbellarian* which manifest themselves as small black spots on the skin.

Turbellarian infection or black spot disease, also 'black *Oodinium*'

Turbellarian

Turbellarians are small oval worms with a thick ciliate coat. Many of these worms can be found on marine fish. Based on my experience, marine fish from Hawaii and neighboring islands in particular are regularly infested with these worms. Usually, black spots are distributed over the entire body (fewer on fins, sometimes on gills). These parasites are easily recognized on light-colored fish such as Yellow Tang (*Zebrasoma flavescens*) (*Figure 58*).

At first, infected fish dart around nervously. However, they later become listless. Skin and eyes become covered with a cloudy mucus membrane layer and respiration is accelerated. In very advanced stages, skin hemorrhaging occurs. Inevitably, the fish contracts secondary bacterial infections accompanied by skin and fin rot.

When a skin smear is placed on a slide (in some seawater), the small worms (up to 0.5 mm) can be clearly seen under the microscope. Low power magnification (50 - 100x) is enough to see the oval form with the thick ciliated coat (*Figures 59, 60*).

Treatment

The following methods can be used to treat infected fish:

- one 10 to15-minute freshwater bath daily on five consecutive days; or
- 1 mg/l or 1 ppm trichlorfon on three consecutive days; or
- 2 g/100 l picric acid, for one hour.

Figure 58

Black spot infection, clearly visible on the side of a Yellow Tang *(Zebrasoma flavescens).*

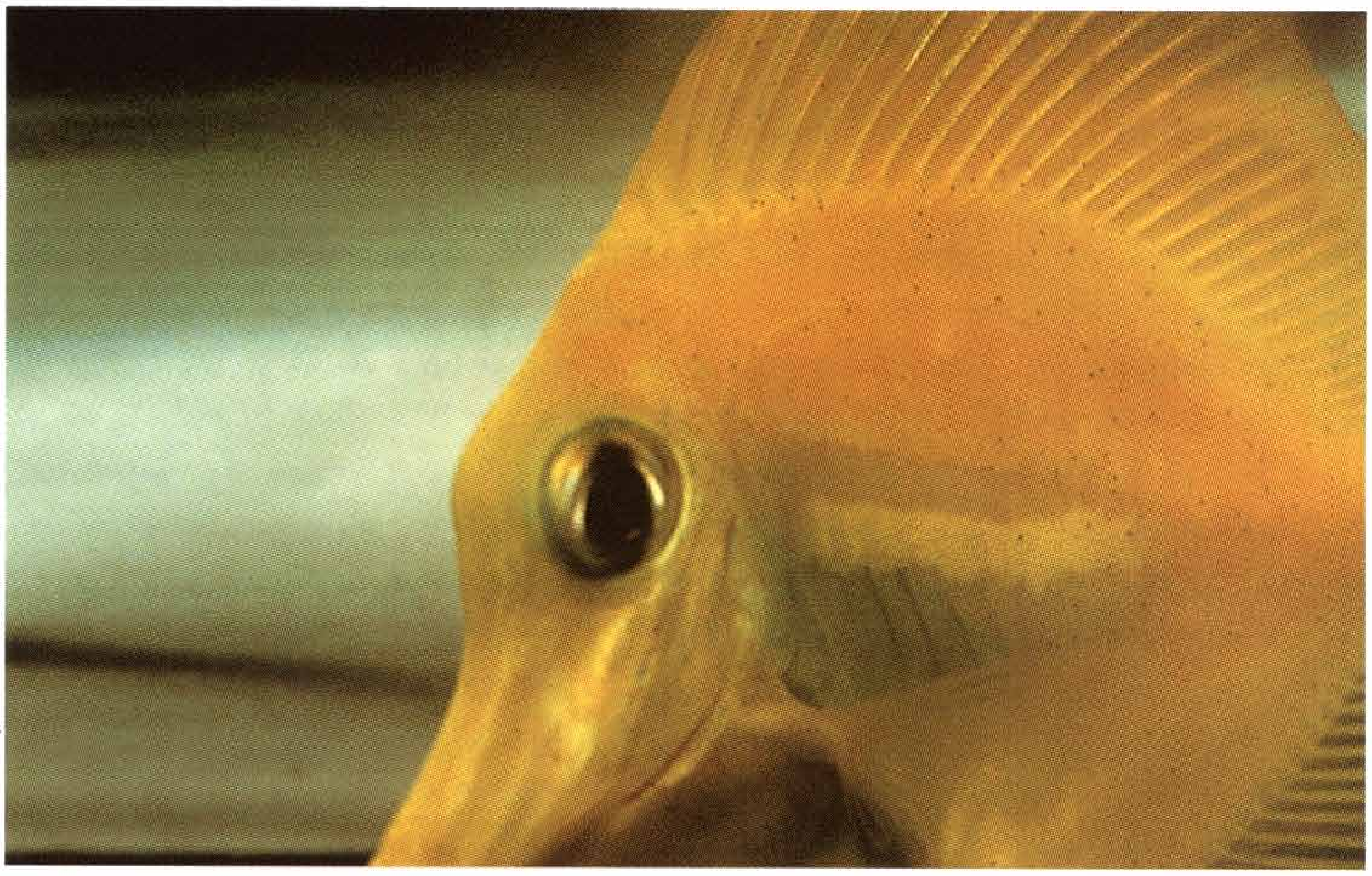


Figure 59

100x microscopic magnification of three black spots of *Turbellarian* worms on a part of fin.

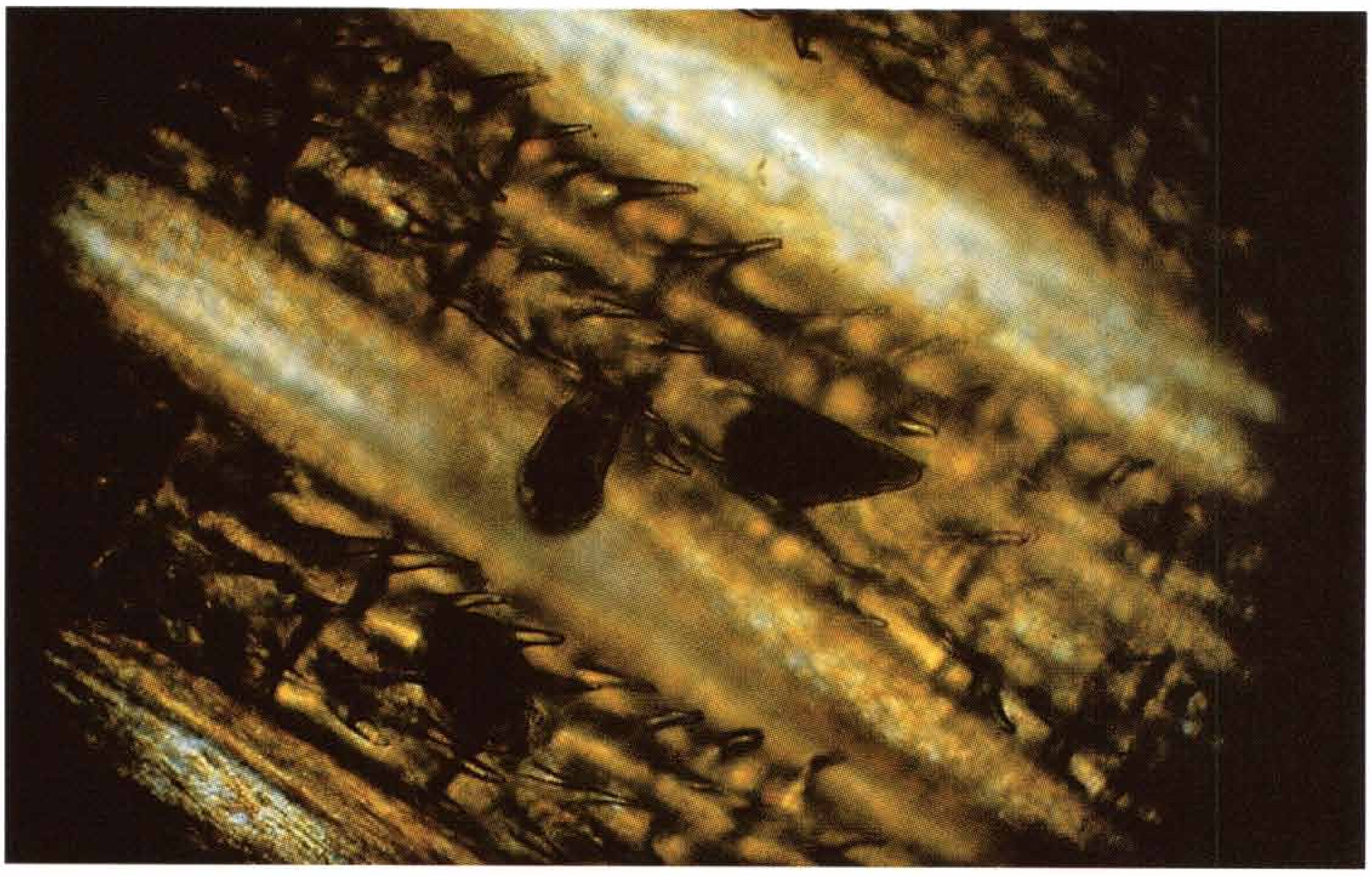
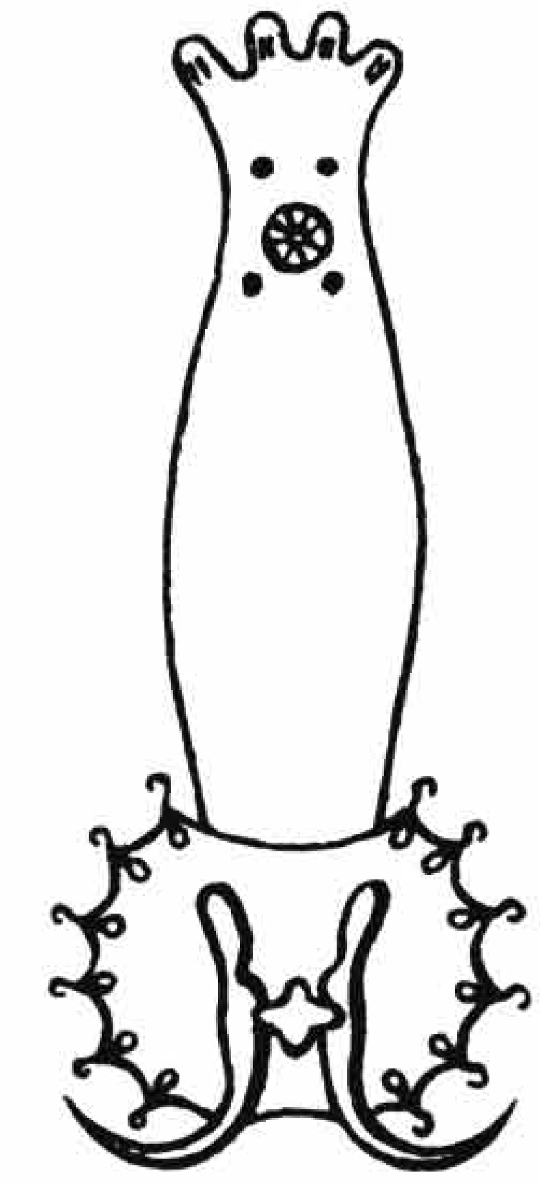


Figure 60

200x magnification of a *Turbellarian.*

Skin and gill worms: monogenetic *Trematodes* (life cycle without intermediate hosts)



Gill worm or Trematode

Gill worms occur mostly in Butterflyfish (*Chaetodon, Forcipiger, Chelmon, Heniochus* etc.) and Angelfish (*Holacanthus, Centropyge, Pomacanthus* etc.). However, these are not found in fish as often as sometimes claimed.

If individual gill worms are found, the fish are not seriously damaged. Nevertheless, infestation may spread quickly and gill worms will use their hooks to seriously damage gill tissue, giving rise to secondary bacterial infections and death from suffocation. Skin worms, monogenetic Trematodes such as *Benedenia sp.* also occur occasionally. Gill worms such as *Cleiodiscus, Dactylogyrus, Entobdella* and *Microcotyle* occur much more frequently.

Typical symptoms are difficulty in respiration, opened gill covers, fish hanging at the surface and gasping for air, laying on the bottom, loss of weight, scraping (with open gill cover) along the bottom of aquaria and against corals (*Figure 61*).

The small curved worms (size, 0.05 to 1.0 mm) can be seen under the microscope in skin and gill smears. The worms are firmly hooked into tissue. 100x magnification is sufficient to see these worms (*Figures 62, 63*).

Treatment

The best results are achieved with trichlorfon (Masoten®, Neguvon®, Dylox®) although this is very toxic to tropical fish and invertebrates. Consequently, fish must be observed carefully during treatment. Also Praziquantel can be very effective when applied as a bath for 24 hours (and repeated after 7 days). Formaldehyde, in the form of a short bath, also effectively kills these parasites. But, this treatment may stress the fish, weakening them.

A freshwater bath is a very simple and effective method of treatment. We should repeat the treatments after 7 days to kill possible newborn worms.

It is recommended that antibacterial agents be administered against any possible secondary bacterial infections.

Figure 61

Weight loss in a Coral Butterflyfish *(Chaetodon xanthurus)* with a gill worm infection.

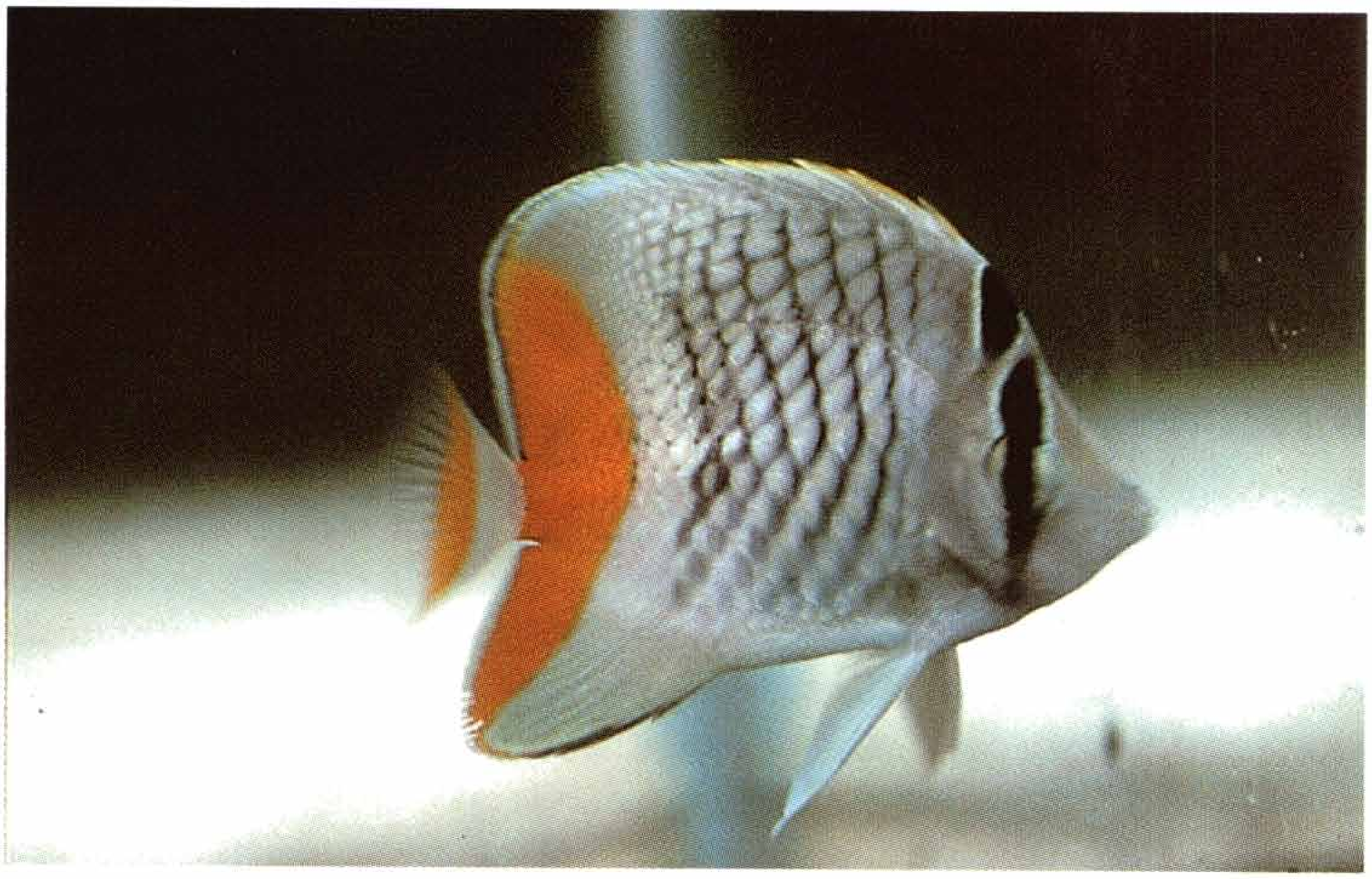


Figure 62

Gill worms (3) or monogenetic Trematodes, firmly attached to the gill tissue (100x magnification).

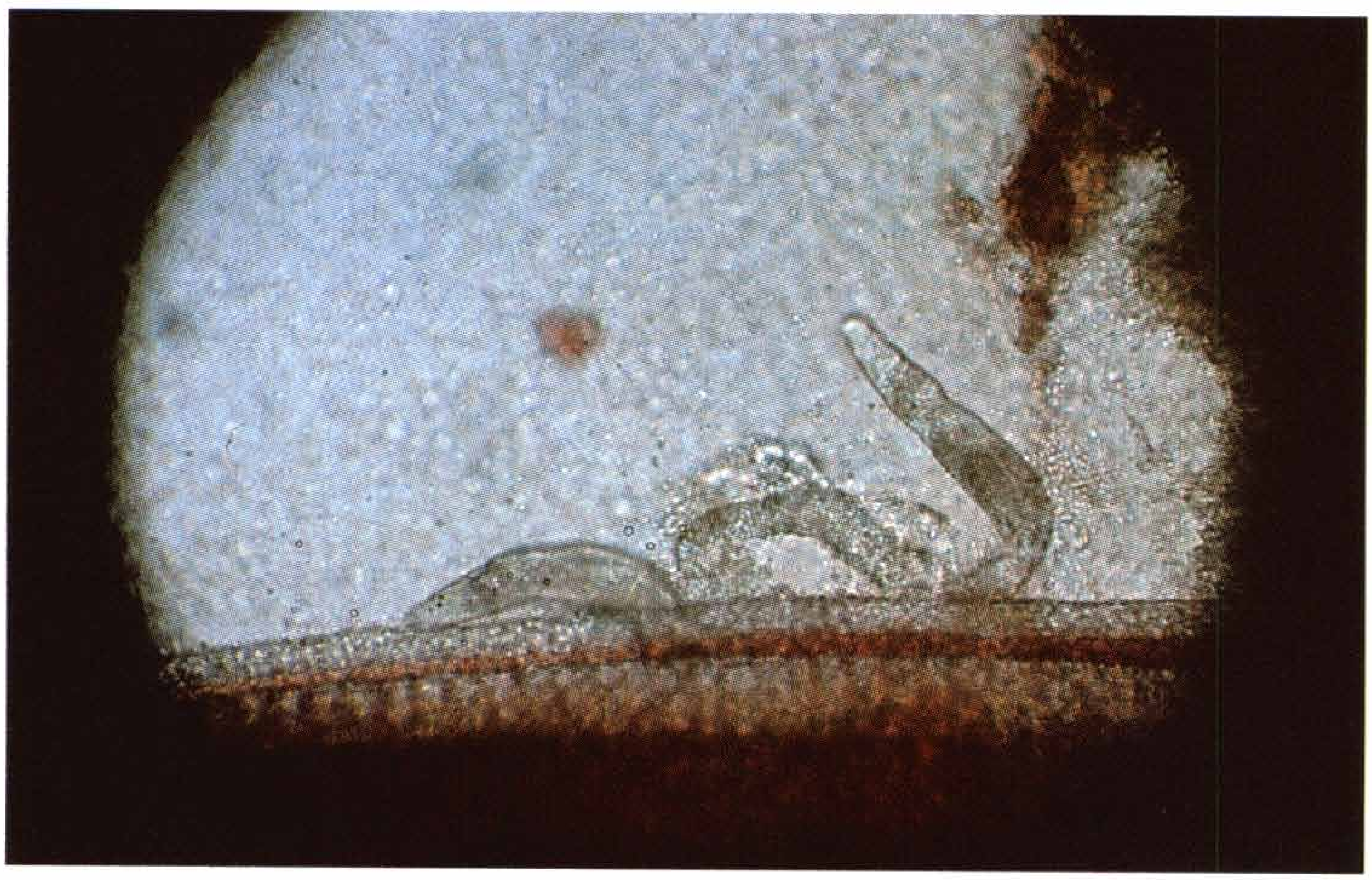
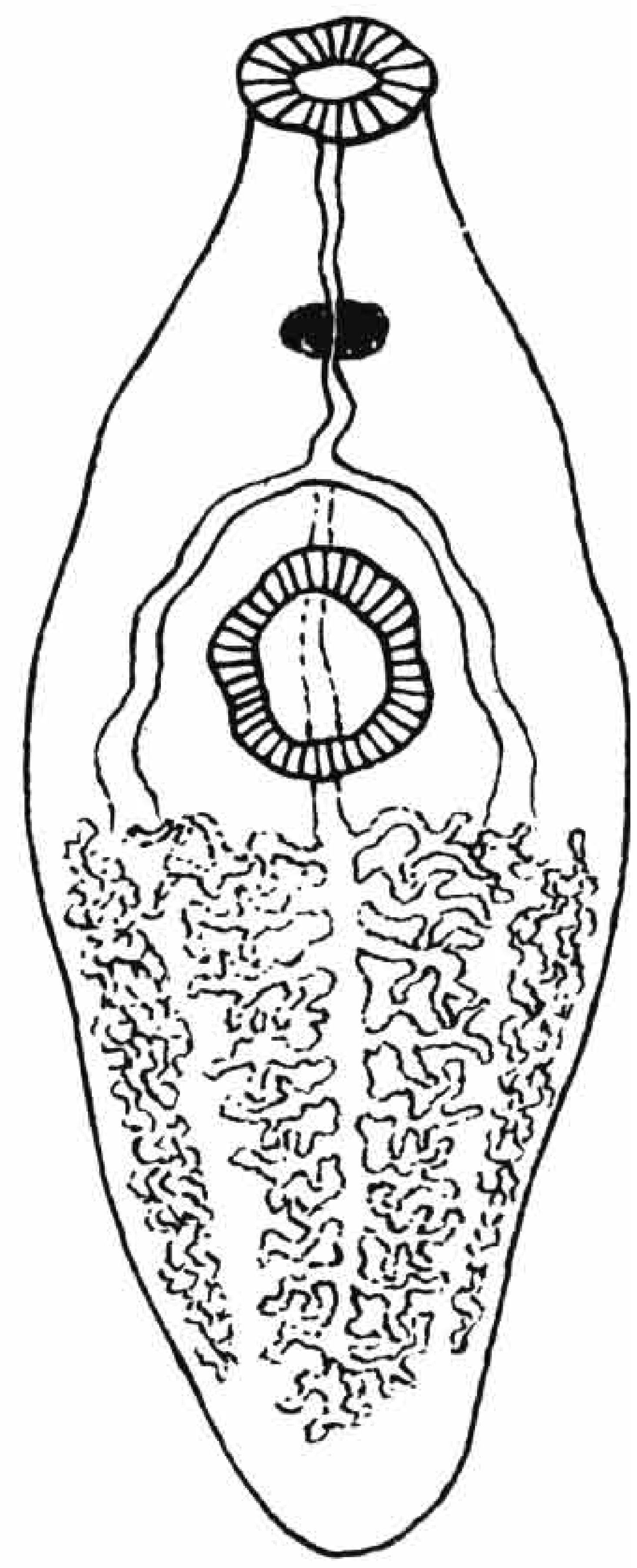


Figure 63

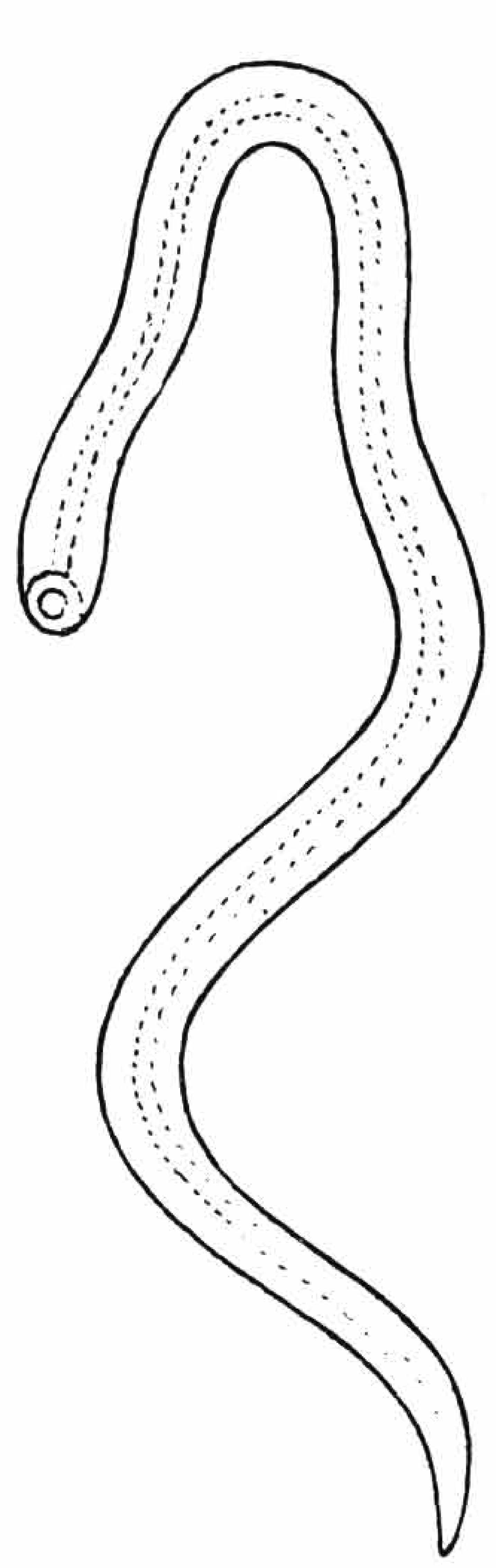
Typical moving gill worm, firmly attached into the gill tissue (100x magnification).

Internal worm infections

Digenetic *Trematodes* (or *Metacercaria* = larva) and *Nematodes* (round worms) are found mainly in the intestines, the liver and the mesentery of tropical marine fish. Small numbers of *Cestodes* (tape worms) or *Acanthocephalans* are occasionally found.
Internal worm infections are found in approximately 70 to 85% of tropical marine fish imported from the Philippines, Indonesia, Sri Lanka, Hawaii, the Caribbean, Australia, and the Red Sea. This is a normal phenomenon in natural environments of marine fish where they constantly come into contact with worms. This is normally due to eating smaller marine animals (shrimps, crustaceans, plankton, etc.) infected with the worm larvae. In most cases, worms cause minor damage. The situation can worsen quickly if the worms multiply rapidly or if the fish is weakened by poor conditions (transportation, poor diet, diseases, etc.). In these cases, the fish can become weak and even die.
Typical symptoms are weight loss, but with a healthy appetite at initial stages of infection. The fish then lose their appetite as the disease progresses. They scrape along the bottom of the aquarium, and against corals, and become listless. In advanced stages, the fish suffer from secondary bacterial infections, which may cause the fish's health to deteriorate rapidly (*Figures 64, 66, 70, 71*).
These internal worms also infect freshwater fish; skin and gill worms appear more frequently than in marine fish, while C*estodes* occur less often.
The worms, which live in body cavities, can be detected during examination of internal organs (intestines, liver, abdominal cavities) (*Figures 70-72*). *Nematodes* are easily identifiable by their elongated cylindrical form. Their length varies from 0.5 to several millimeters. *Metacercaria* or larvae of digenetic *Trematodes* (flatworms) are flat, oval shaped, with suckers which they use to attach themselves to hosts and leech nutrients. Their size varies between 0.1 and 2 mm (*Figures 64-69*).
Cestodes or tape worms are usually longer and have a chained structure. *Acanthocephalans* have a typical hook rostrum (proboscis), which can severely damage the intestines. Their length is between 0.1 and several millimeters. *Cestodes* can even be several centimeters long.
Use low power magnification to examine these worms (50x to100x).



Digenetic Trematode or Metacercaria



Round worm or Nematode

Treatment

Fish must be kept as healthy as possible by providing them with suitable living conditions. Drug treatments can be administered with food if the fish are still eating. Piperazine, thiabendazole, mebendazole, praziquantel, niclosamide or levamisole are effective in the treatment of internal worm infections.

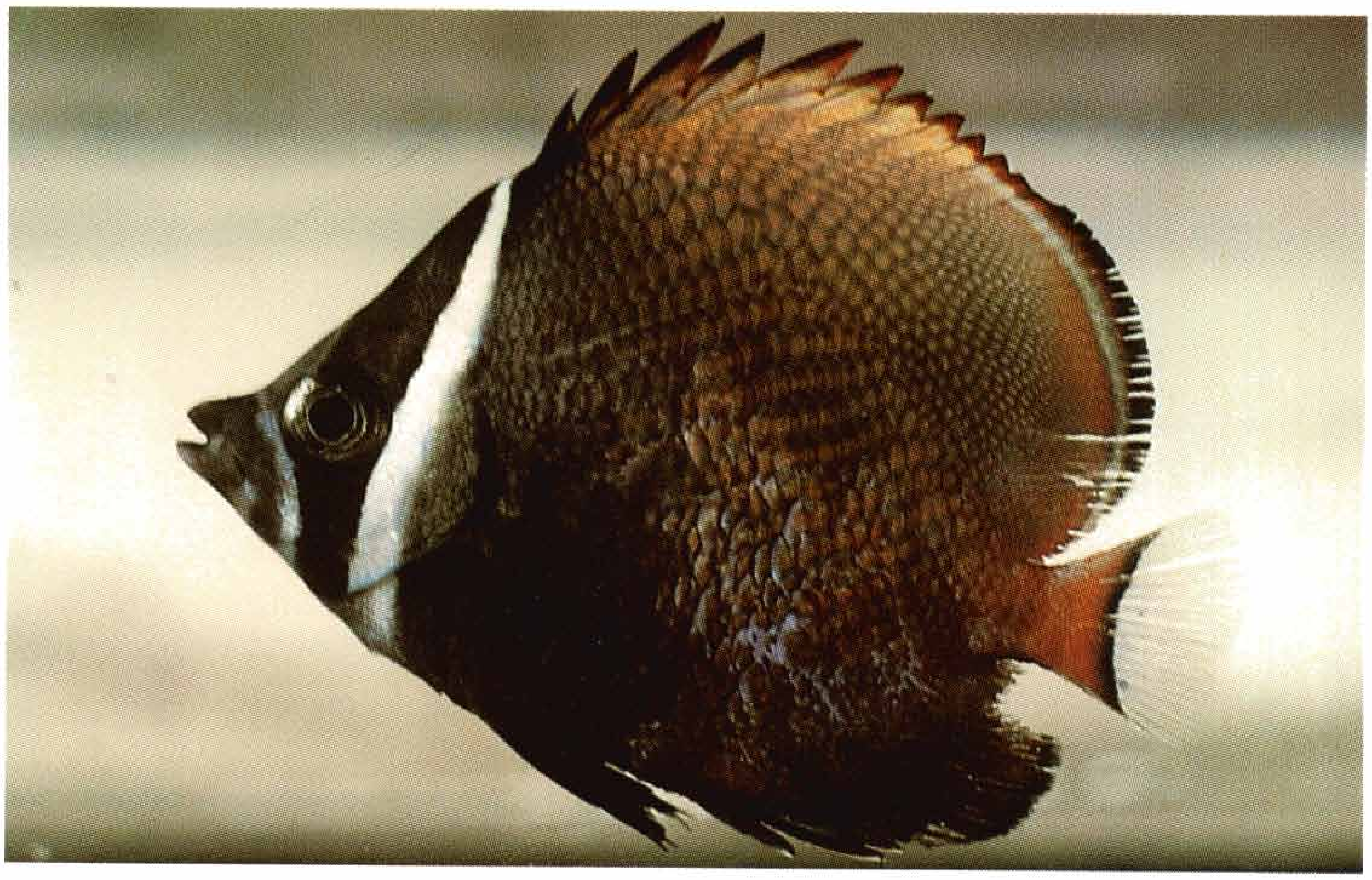


Figure 64

Scale loss, pale skin patches and fin rot as bacterial secondary infection accompanied by weight loss due to internal worm infection in a Pakistani Butterflyfish *(Chaetodon collaris)*, caused by digenetic *Trematodes* (*Metacercaria*).

Figure 65

Digenetic *Trematodes* or *Metacercaria* with their two typical suckers. One is stretching slowing in the intestines.

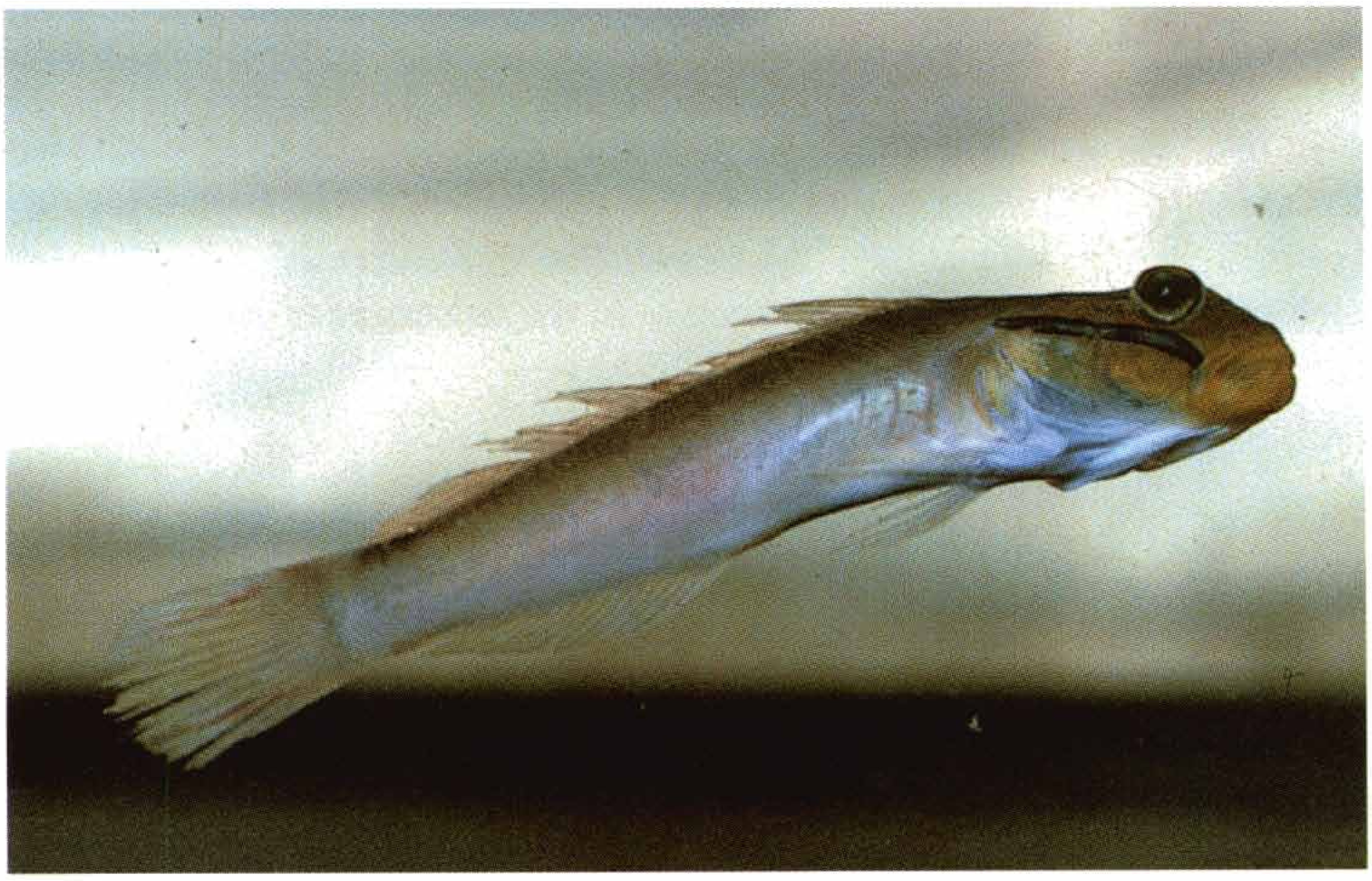


Figure 66

Golden headed sleeper *(Eleotriodes strigatus)* with frayed fins and extreme weight loss due to internal worm infection caused by digenetic *Trematodes* or *Metacercaria*.

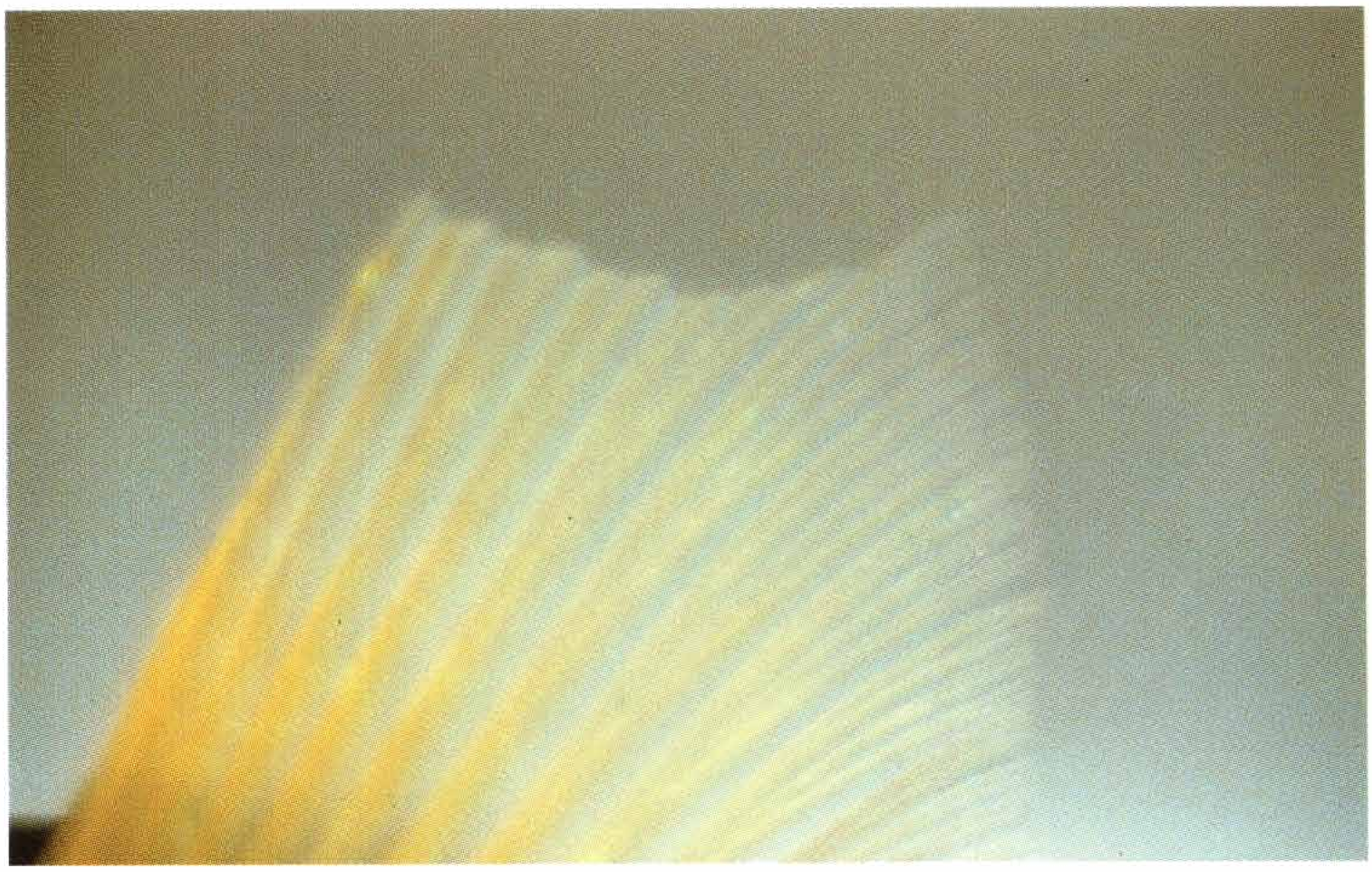


Figure 67

Small white spots in the fin rays of the pectoral fin of a Blue Angelfish *(Holacanthus isabelita)*, caused by encapsulated *metacercaria* (digenetic *Trematodes*).

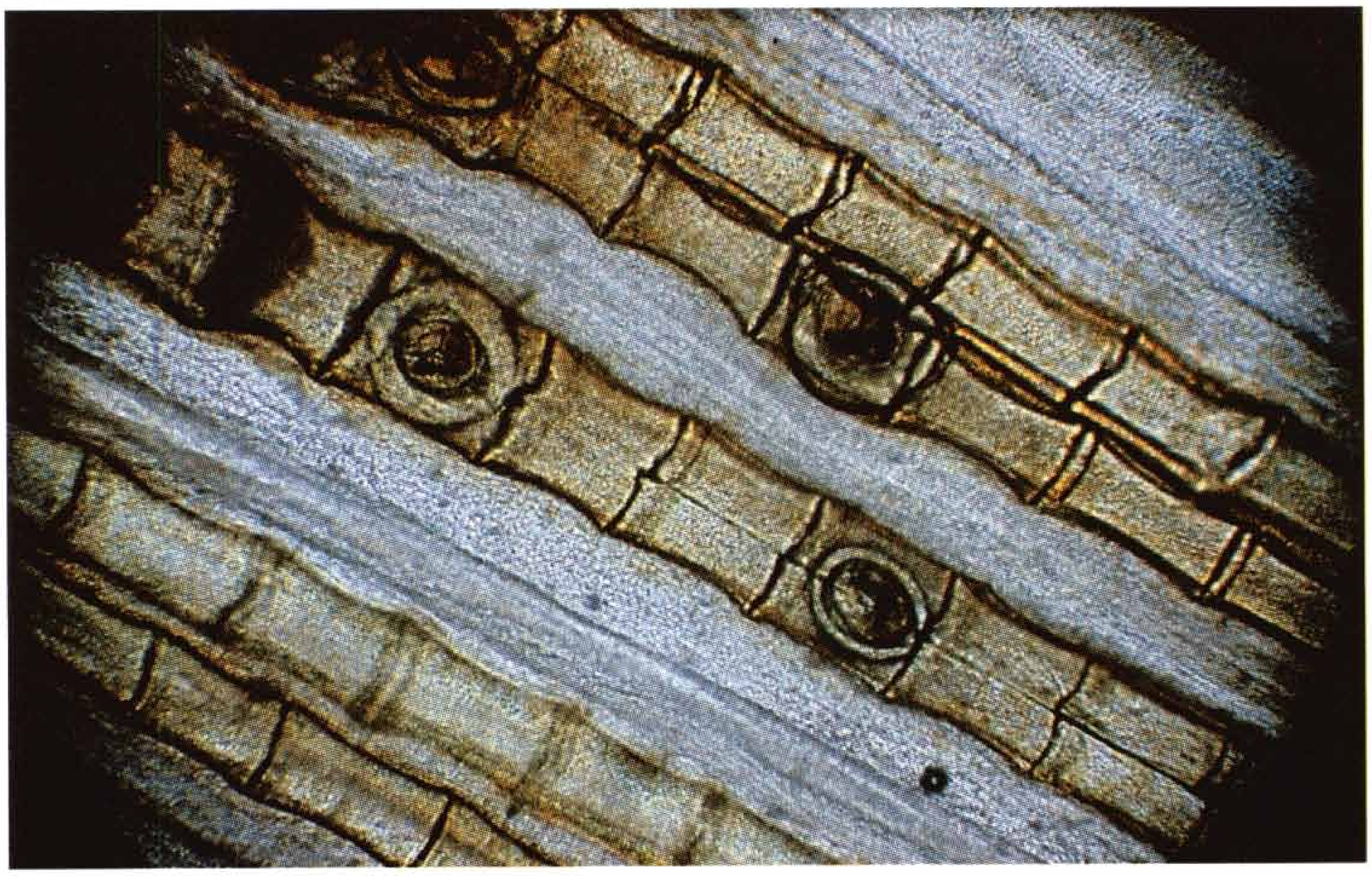
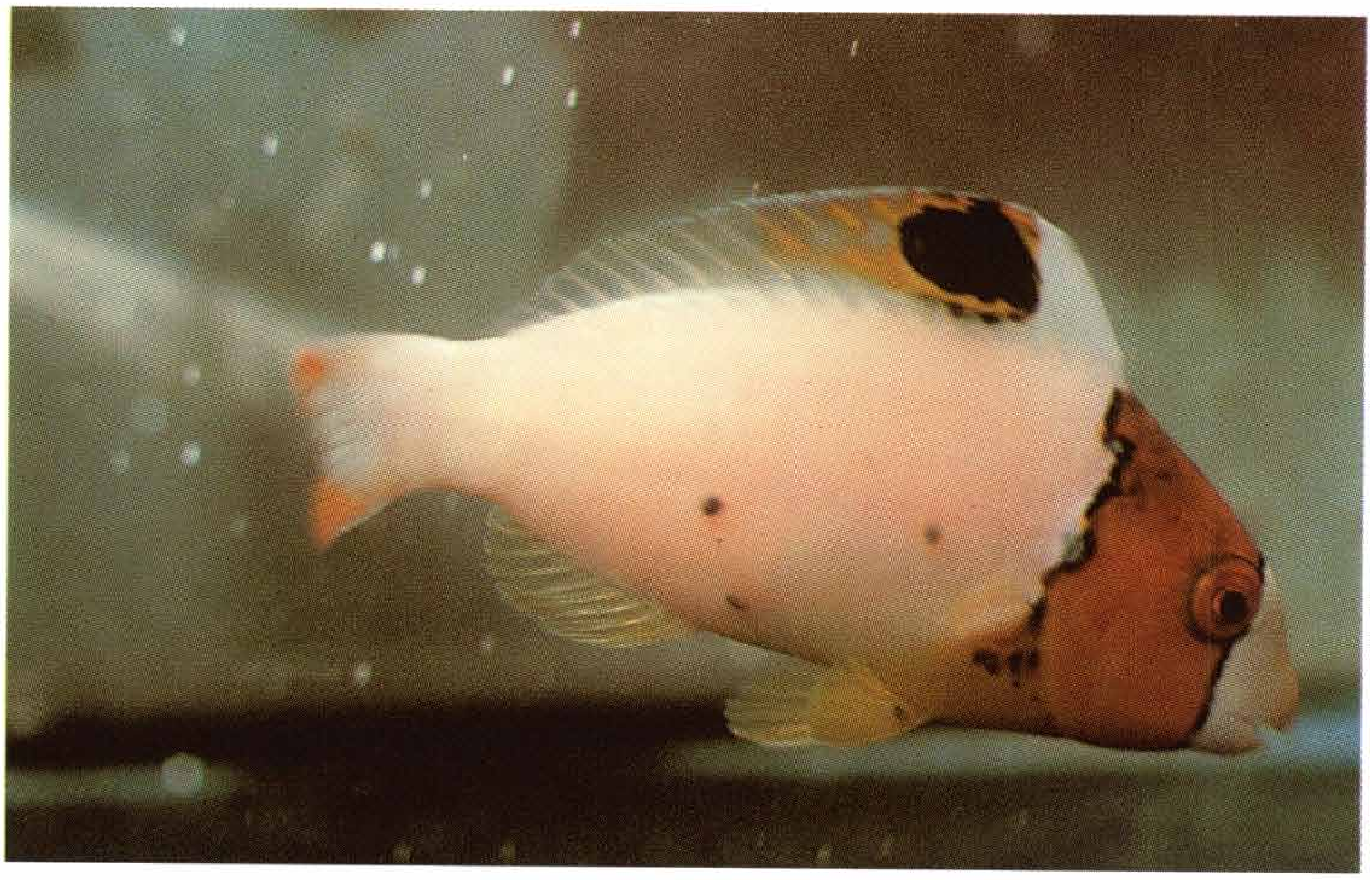


Figure 68

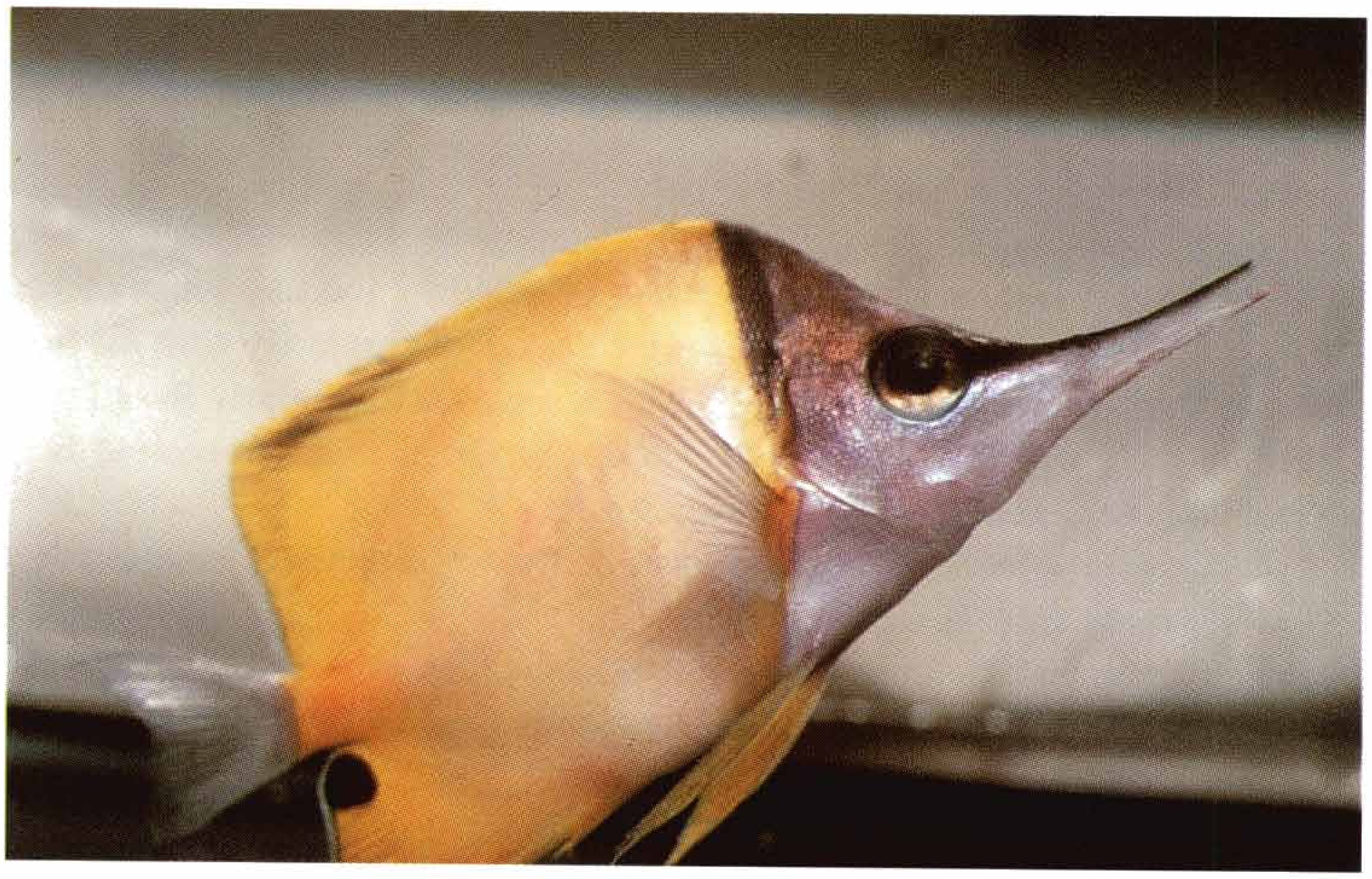
100x magnification of a pectoral fin with its fin rays and encapsulated digenetic *Trematodes* or *Metacercaria*.

Figure 69



Black spots in the skin and muscular tissue of a Two Colored Parrotfish *(Bolbometopon bicolor)*, caused by encapsulated digenetic *Trematodes* or *Metacercaria*.

Figure 70



Long Nosed Butterflyfish *(Forcipiger flavissimus)* exhibiting weight loss caused by an internal *Nematode* infection.

Figure 71

Clown Wrasse *(Coris angulata)* exhibiting weight loss and secondary bacterial infections (fin rot, pale and red patches), originally caused by an internal *Nematode* infection.

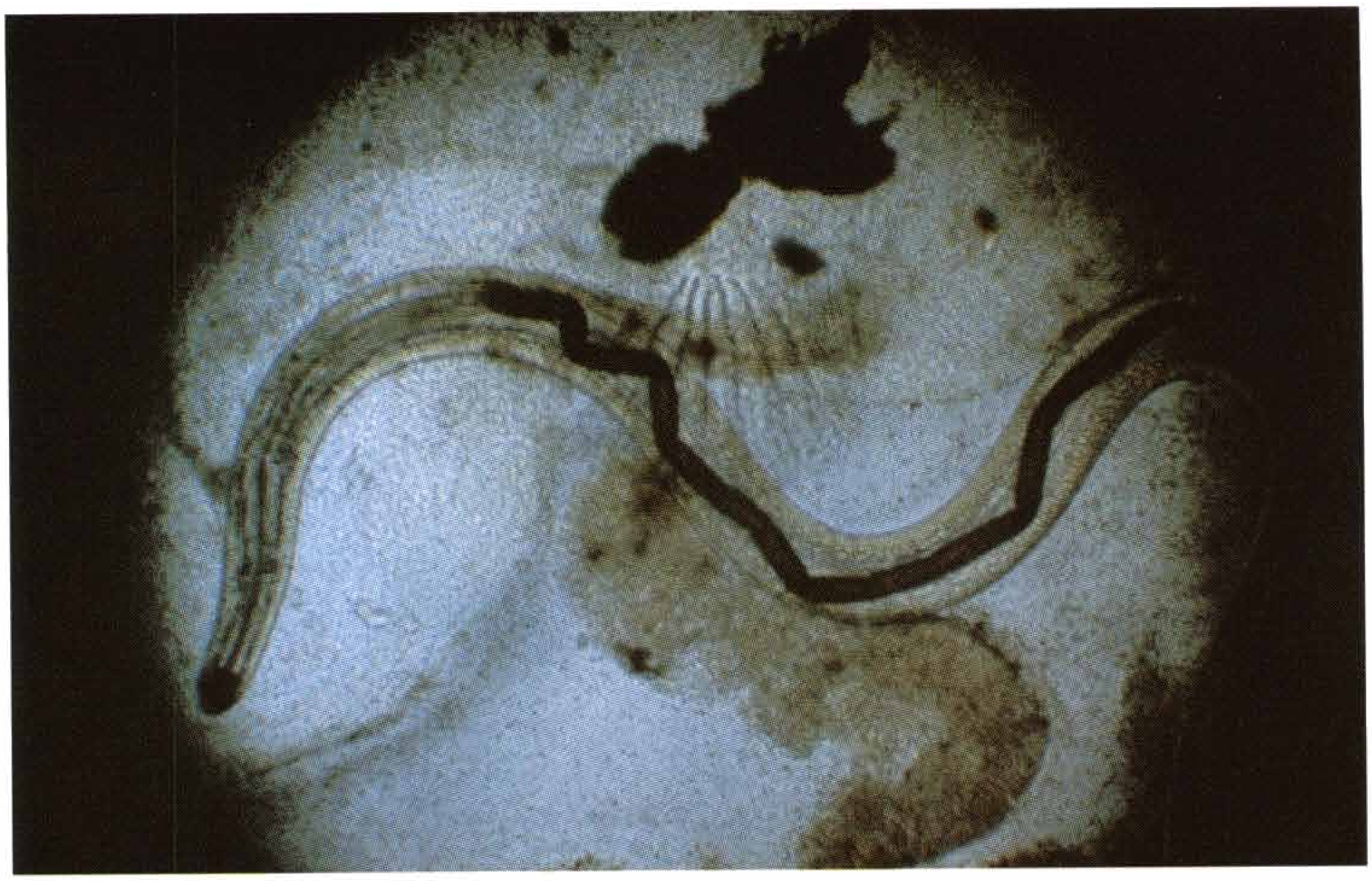
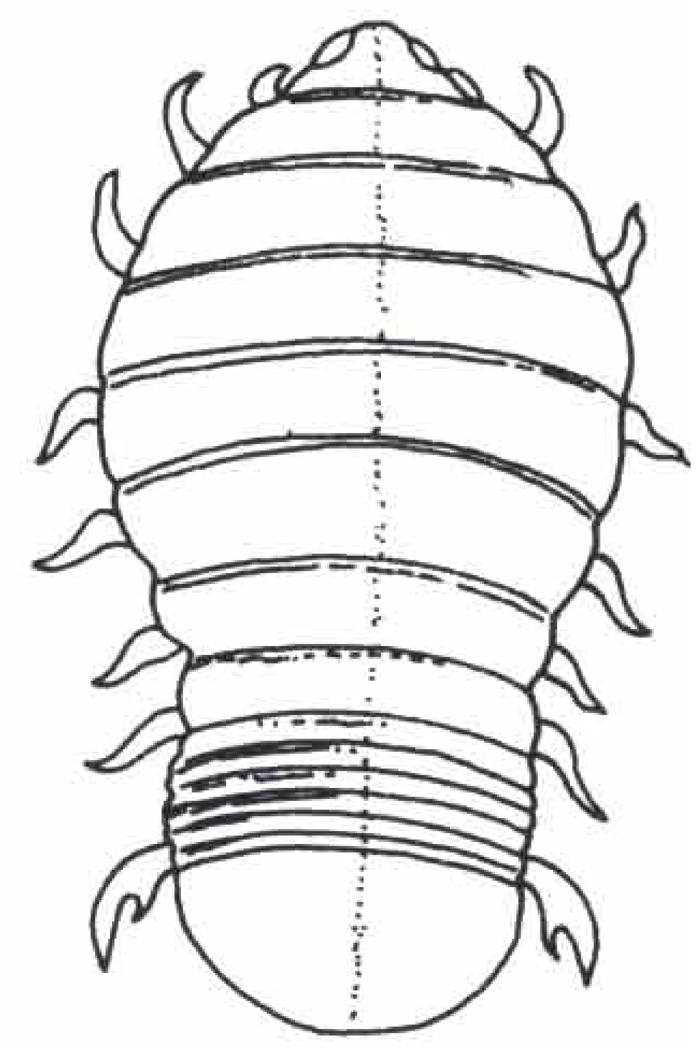


Figure 72

A *Nematode* or round worm *(Camallanus Sp.)* in the intestine of a Clown Wrasse *(Coris angulata)*.

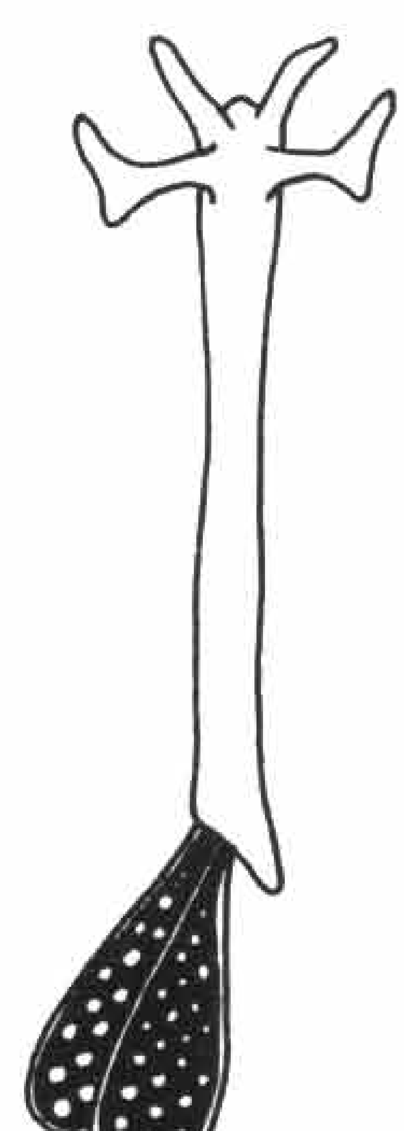
5.3 Parasitic *crustaceans*



Like freshwater fish, marine fish are also infected by the fish louse (here: sea louse), *Livoneca sp.*, which has a great degree of similarity with the lice found in tropical freshwater fish from South America (especially Brazil and Columbia). Copepode infection, known as *Lernaeascus sp.* in marine fish corresponds to *Lernaea sp.* in freshwater fish.
These parasitic infections are common in freshly imported marine fish, especially those from South East Asia.
Both kinds of parasites are easily identifiable by their grotesque appearance on the skin of the fish; other signs are wounds (and ulcers) and secondary infections.
In addition, infected fish lose a considerable amount of weight, are anxious or sometimes listless.

Treatment

Treatment is aimed at killing parasites and free-swimming larvae to prevent new infections and the spread of parasites.
Livoneca sp. are preferably removed by hand or with pincers. With *Lernaeascus sp.* this method is not effective because the parasites are deeply anchored into the body of the fish. Trichlorfon (or other organophosphate) (100 mg/100 l) can effectively kill these parasites (and their larvae). Dead *Lernaeascus sp.* can be carefully removed with pincers. They sometimes fall off by themselves. In the case of *Livoneca* infections, trichlorfon should also be used to kill larvae.
Antibacterial agents should also be administered against bacterial infections.



Lernaeascus sp.

Figure 73

A Blue Damsel *(Abudefduf cyaneus)* with a fish louse *(Livoneca Sp.)* on its back.

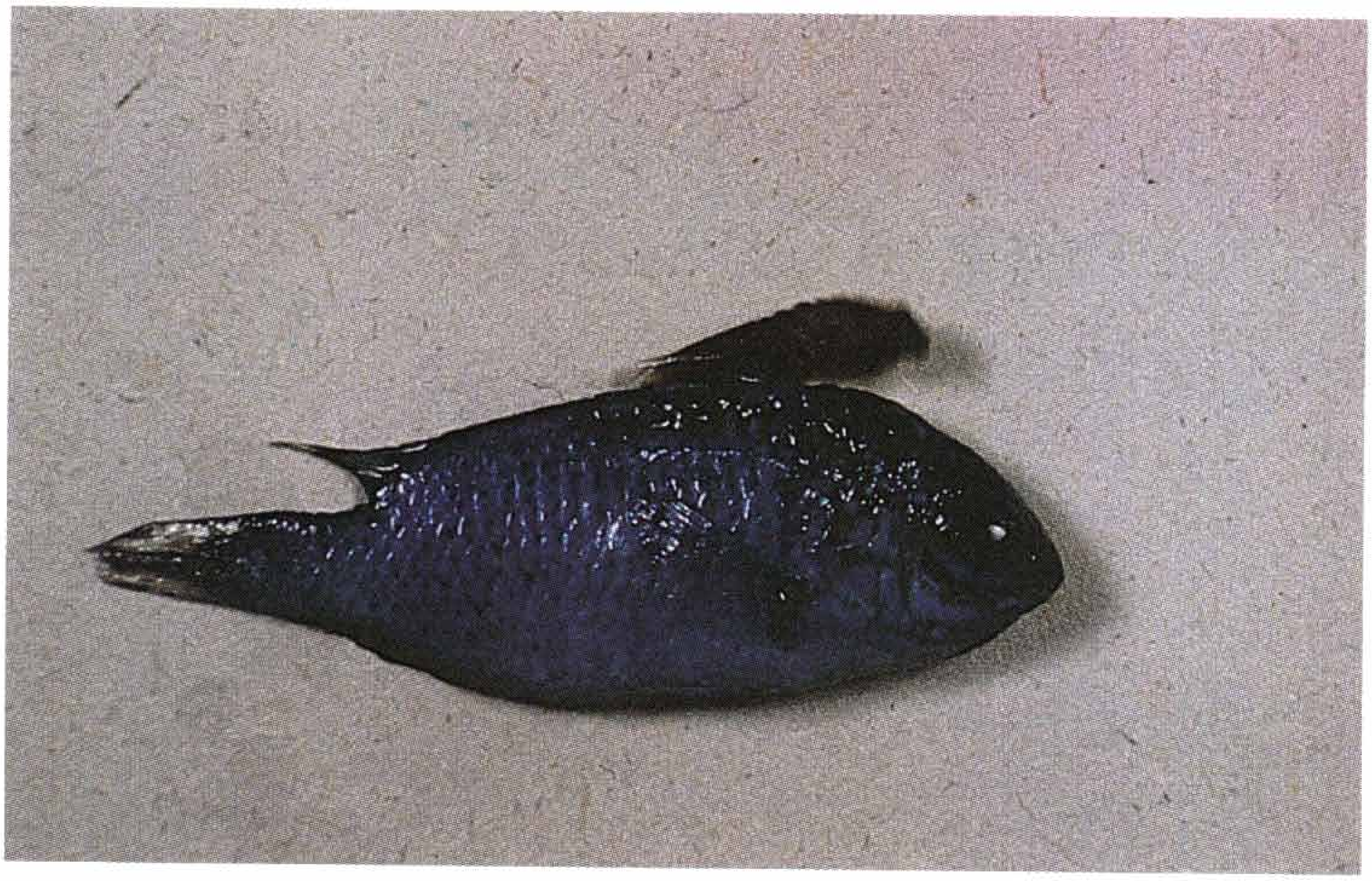


Figure 74

A *Genicanthus melanospilus* with a *Lernaeascus* parasite as "black worm" on its back and a wound caused by the same parasite.

Treatment of diseases in survey

1. Basic instructions

When treating diseases in marine fish, the following points should be considered:

- the sooner diseases are discovered, the greater the chances of curing them;
- it is vital to determine whether environmental factors are actually primary causes for diseases (e.g. too low pH, too much ammonia or nitrite, not enough dissolved oxygen);
- if antibacterial drugs are administered, fish should be isolated in recovery tanks;
- invertebrates should sometimes be removed from the aquarium (e.g. when treating with copper sulfate or trichlorfon); **but important to know**: invertebrates (=corals) can control epidemic infections because they can "eat" the juvenile one-cellular parasites (i.e. *Cryptocaryon* and *Oodinium*).
- before starting treatment, 20-35% of the aquarium water should be changed;
- during treatment with drugs, activated carbon filters should not be used in the aquarium;
- the exact volume of the aquarium should be known so that drugs can be administered in the correct doses.

As mentioned in the chapter 'Diseases in Marine Fish: what factors play a role?', water quality must be examined first for any factors which may be harmful to the fish (e.g. stress). If the pH is too low or there is excessive ammonia or nitrite, fish may be weakened and become more susceptible to disease.
If you determine that a virus, bacteria, fungus or parasite is the primary cause of infection, it is important to select the proper drug treatment. At the same time, you must decide whether the whole aquarium should be treated. When household aquaria with biological filters are being treated with antibacterial agents, 'good' nitrifying bacteria are also killed with 'bad bacteria'. Consequently, it is sometimes better to treat the fish in a *treatment tank*. These tanks must have the usual hiding places, sand,

case, the water must be examined regularly for possible fluctuations of ammonia and nitrite concentrations. After 3 to 4 days, a large proportion of the aquarium water must be replaced. During treatment in treatment tanks, part of the water must be changed daily and the respective drugs added.
Based on my own experience, *a short or long bath* is the best treatment method, e.g. a 5 to 15-minute freshwater bath. Chloramphenicol and nitrofuran can also be added to the water for 3 to 4 days. *Drugs* may also be administered *in food*, although you cannot be certain that the fish actually ingest the drugs or that they receive sufficient doses. If the drug is placed in water, it is possible that fish will drink a certain amount. Marine fish drink saltwater to maintain their fluid balance.
Sometimes, antibiotics can be combined to increase their efficacy. This applies when treating parasitic infections and if there are also secondary bacterial infections. For example, fish infected by *Cryptocaryon* may also contract secondary bacterial infections due to damaged skin and gill and their weakened condition. In such cases, both parasites and bacteria must be treated (e.g. with formaldehyde-malachite green-furaltadone-nifurpirinol).
Preferred treatment will be mentioned in descriptions of individual diseases and their treatment.
A caution on mixing drug treatments: copper sulfate should not be combined with neomycin or sulfonamides, because poisoning will result.
Check with your local aquarium shop: many good commercial fish medicines are available!

Conversions:

1 liter (l) = 0.264 gallon
1 milliliter (ml) = 0.001 liter
= 0.003 gallon
= approx. 20-25 drops
1 gram (g) = 0.0353 oz.
1 milligram (mg) = 0.001 gm

2. Antibacterial drugs

As mentioned in the chapter entitled 'Bacterial infections', most keepers of tropical marine fish find it very difficult to determine which bacteria are responsible for a given bacterial infection. When tropical marine fish are sick, you need to act as quickly as possible to cure them. As a result, you should use antibacterial agents which you hope will cause infections to subside. If necessary, combination preparations can be administered to kill or combat bacteria across a broad spectrum (Neomycine - nifurpirinol or neomycin-sulfonamides). If, after 3 to 5 days of treatment with a specific agent (or combination preparation), no improvement is observed, it is possible that other non-bacterial, pathogens are responsible for the disease, such as parasites (*Brooklynella*, *Uronema*, etc.). It is also possible that some bacteria do not react to certain antibacterial agents or are resistant to them. In these cases, an alternative antibacterial preparation should be used or a combination of different preparations after changing 30 to 50 % of the water in the aquarium and/or filtering the water over activated carbon for 24 to 48 hours. Treatment with antibiotics should take place in separate recovery tanks. If this is not possible, the water quality in the usual aquarium should be monitored regularly and if possible the biological filter cut off.
NOTE: Many antibacterial drugs are only available upon prescription and some are legally restricted in several countries.

Erythromycin

Dosage: 1.0 g/100 l; 3 days
Application: For treating fin rot, raised scales in case of swollen belly, especially in *Corynebacterium* infections (kidneys).

Isoniazide

Dosage: 1.0 g/100 l; 3 to 4 days or subsequent dose after 30 to 60 days
Application: This drug is recommended by different authors for treating marine fish tuberculosis (*Mycobacterium marinum*), although results are moderate. It should only be used if there is no other suitable treatment.

Kanamycin

Dosage: 2.0-4.0 g/100 l; 2 days
Application: In several books, this preparation is recommended for tuberculosis in fish (*Mycobacterium*), although results with tropical fish are not convincing.

Linco-Spectin 100®
(lincomycin-spectinomycin, Upjohn)

Dosage: 0.5 g/100 l; 3 days

Application: For the treatment of fin rot, white spot disease and several bacterial infections. However, this antibiotic is not recommended for home aquaria as it also kills nitrifying bacteria and algae.

Neomycin (sulfate)

Dosage: 4-6 g/100 l; 3 days

Application: For treating numerous bacterial infections, caused by *Myxobacteria, Pseudomonas, Aeromonas* and many other bacteria.

One of the most effective antibiotics even for tropical marine fish, it can be combined with sulfonamides, nifurpirinol or tetracycline, *however, never with copper sulfate.*

Nifurpirinol = (100 % fish medicine)

Dosage: 20-30 mg/100 l; 1 to 3 days. If necessary to repeat after a water-change

Application: For treating numerous bacterial infections against which furan drugs are administered. This drug can also be given in a short bath, 5 to 15 minutes at a dosage of 20 to 30 mg/l. Nifurpirinol is contained in Aquafuran® (manufacturer: Aquarium Münster) Furanace® (manufacturer: Aquarium Systems) and Prefuran® (manufacturer: Argent Chemicals).

Nitrofurazone or Furaltadone

Dosage: 1.5 g/100 l; 3 to 4 days

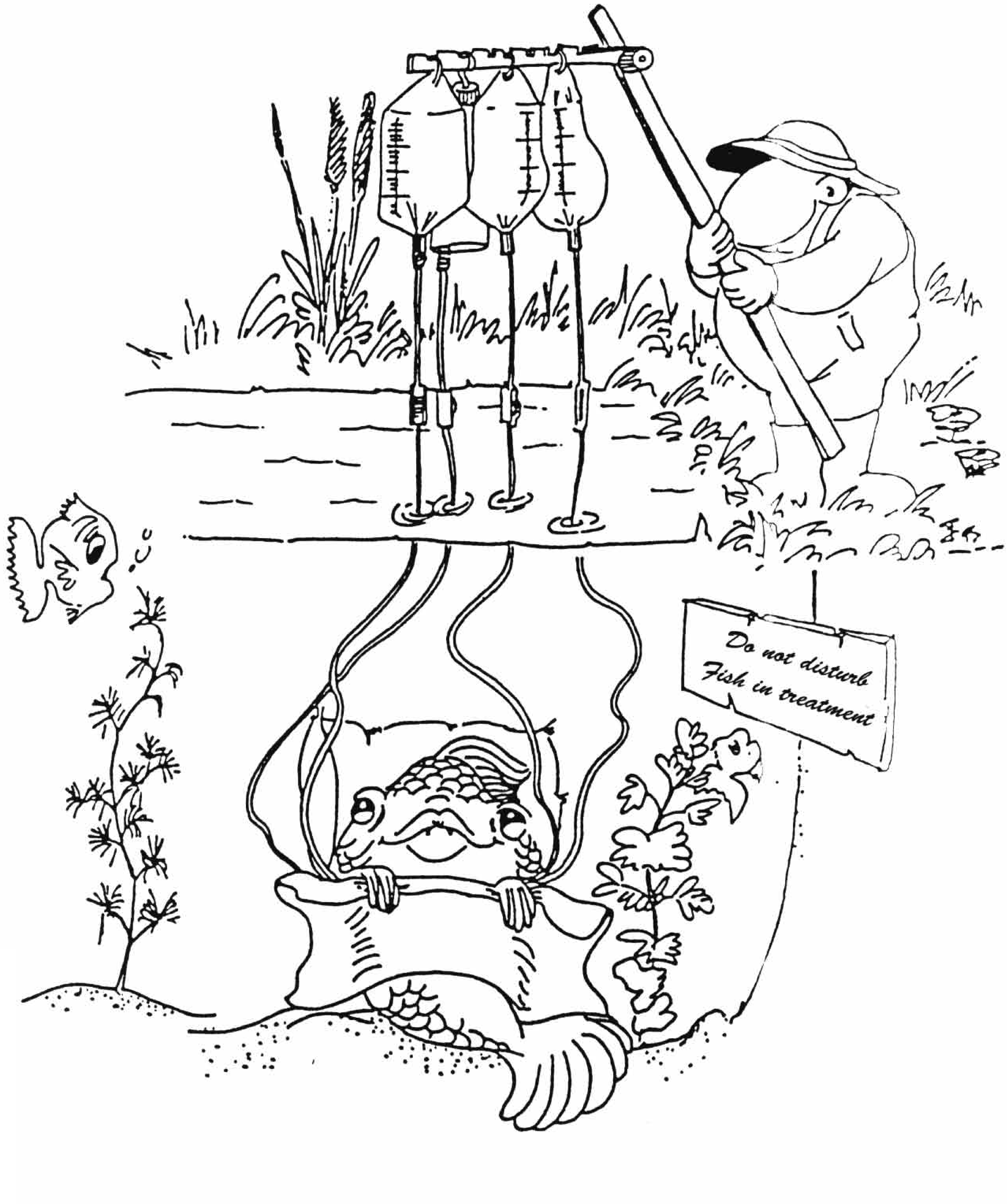
Application: This drug is used to combat numerous bacterial infections such as fin and tail rot, skin inflammation, white spots etc. If necessary, it can be combined with neomycin.

Also to use: Furaltadone

Penicillin

Dosage: 1-3 g/100 l; 2 days

Application: This drug can be used to combat fin rot. When combined with streptomycin, it can also be used to treat several bacterial infections in connection with red or white spots.


Do not disturb
Fish in treatment

Rifampin

Dosage: 50 mg/250 g food, 10 days or longer

Application: This drug is recommended by American aquarists for treating marine fish tuberculosis (*Mycobacterium marinum*).

Streptomycin

Dosage: 2.0-4.0 g/100 l; 2 to 3 days

Application: For treating red skin inflammation, fin rot, marine fish tuberculosis (*Mycobacterium marinum*) and other bacterial infections.
Water may have a repulsive onion-like odor after 1 to 2 days. Streptomycin can be combined with penicillin.

Sulfonamide, sulfanilamide

Dosage: 10-20 g/100 l; 3 days

Application: See sulfathiazole

Sulfathiazole

Dosage: 0.5-1.0 g/100 l; 3 days

Application: For treating red skin inflammation, eye cloudiness and occasionally other bacterial infections. This drug can be combined well with neomycin, but *never with copper sulfate*.

Tetracycline

Dosage: 2.0 -3.0 g/100 l; 2 to 3 days

Application: Used to treat raised scales and/or swollen belly (ascites, dropsy), swim bladder inflammation and sometimes other bacterial infections.
Water must be exchanged after 1 to 2 days. Accurate dosage required, i.e. quantity of tetracycline is added in accordance with amount of water replaced. Due to the high pH of saltwater, tetracycline is less effective in marine aquaria. It can be used in combination with neomycin to combat other bacterial infections.
Tetracycline can also be administered in food (dosage: 100-250 mg/100 g of food over a period of 7 to 14 days) to treat *Vibrio* infection, dropsy, swim bladder inflammation etc.

3. Combinations of antibacterial agents

When antibacterial agents are combined, their effectiveness against bacteria is increased. Some drugs are *synergetic* (i.e. are more effective in combination) so that bacteria have less chance of surviving.
Antibiotics or chemotherapeutics cannot be combined without careful checking against toxicity. Only the following combinations or others suggested by specialists should be used:

Neomycin (1.0 g/100 l) — nitrofurazone or Furaltadone (1.0 p/100 l) a period of 2-3 days;

Neomycin (1.0 g/100 l) — sulfathiazole (0.5 g/100 l) over a period of 2-3 days;

Neomycin (2.0 g/100 l) — tetracycline (2.0 g/100 l) over a period of 2-3 days;

Penicillin (1.0 g/100 l) — streptomycin (1.0 g/100 l) over a period of 2-3 days;

Lincomycin — spectinomycin = Linco-Spectin 100® (Upjohn): 0.5 g/100 l over a period of 2-3 days.

4. Other drugs

Copper sulfate ($CuSO_4.5H_2O$)

Stock solution: 4.0 g/l of distilled water to which 0.25 g of crystalline citric acid is added.

Dosage: 0.25-0.30 ppm; initial dose: 25 ml/100 l (see also: F. de Graaf, 1981)

Application: Copper sulfate is used especially to treat *Oodinium* and *Cryptocaryon*. In aquarium water, copper sulfate combines with carbonates from sand, coral and stones. The degree of combination depends on the pH, O_2 content, CO_2 content etc.

As a result, when establishing an aquarium, a subsequent dosage is required. 20 ml/100 l should be used over a period of 7 to 14 days. If fish are jumpy or irritable, some of the water must be changed and the dosage reduced. If fish are placed into a treatment tank, 12.5 ml/100 l must be added in the first 48 hours, and 6 ml/100 l after 96 hours.

Without a *copper test set*, it is difficult to determine the concentration of dissolved copper ions. Treatment may not be effective if under-dosed and is toxic if over-dosed. For effective treatment, 0.25-0.30 ppm Cu ions is needed. The treatment period must be at least 14 days so that all *Oodinium* or *Cryptocaryon* parasites are killed while in the swarming stage. Otherwise, the disease can re-establish itself very quickly.

Copper sulfate can be combined with 37% formaldehyde or methylene blue, *but it should never be* given simultaneously with neomycin or sulfonamides.

WATCH OUT! Invertebrates must be removed from the aquarium during treatment. In newly established aquaria, some nitrifying bacteria may be destroyed when copper sulfate is used for the first time.

Formaldehyde 37 %

Dosage: 1 drop / 4-5 l or 1 ml/100 l

Application: This solution is effective against mostly unicellular parasites such as *Cryptocaryon, Oodinium, Brooklynella, and Uronema*. However, best results come from simultaneous application of malachite green or copper sulfate.

It is toxic for invertebrates. Even minor overdoses can be poisonous for fish.

Freshwater cure

Dosage: A five to ten minute bath, once daily, over a period of 2 to 5 days. If fish exhibit more relaxed behavior, they must be removed from the bath.

Application: To combat unicellular parasites such as *Cryptocaryon, Oodinium, Brooklynella, Uronema*, as well as gill and skin worms, Turbellaria and parasitic *Crustaceans* (fish louse and *Lernaeascus sp.*)

The pH and temperature of the freshwater should be the same as that of the saltwater in which the fish live. The pH can be increased by adding sodium bicarbonate (1 teaspoon/10 liters). The bath water must not contain chlorine. Water can be made dechlorinated by allowing it to aerate for 24 to 36 hours or by adding sodium thiosulfate (1.0 g/10 liters). Marine fish may initially go into shock in freshwater. When they are tapped lightly, they usually begin to swim around again. Nevertheless, if fish remain in shock for more than a few seconds, it is best to put them back into saltwater. The reason is either this freshwater is not suitable or the fish were too weak and sensitive for this drastic treatment. Marine fish with open wounds (normally bloody) should not be treated in freshwater baths. Body fluids and blood are drawn from fish by osmosis, which worsens the condition. On the other hand, with this osmotic pressure, any parasites on skin and/or gills of fish burst and are killed by absorption of additional water.

Parasites are cleaned from fish by this method. It is a practical cleaning method used on newly arriving fish. It helps to prevent parasites from getting into the aquarium.

If tropical fish are to be cleansed of parasites by freshwater, the aquarium must also be treated so that freely swarming parasites cannot re-infect fish.

Levamisole

Dosage: 250 mg/100 g of food over a period of 7 to 10 days

Application: To combat *Nematodes* and *Acanthocephalans*.

Malachite green (zinc-free oxalate)

Stock solution: 5.0 g/l of distilled water

Beginning dose: 1 ml or 20 to 25 drops/100 l

Application: Primarily, malachite green is used to combat *Cryptocaryon, Brooklynella, Uronema, Trichodina* etc.

Subsequent dosing is usually required: second day: 1 ml/100 l; third day: 0.5 ml/100 l; fourth day: 0.25 ml/100 l. Treatment must be continued over at least 10 to 14 days so that all free swimming parasites are killed.

Malachite green can be combined with formaldehyde 37 %. Lower life forms tolerate malachite green quite well and so do not need to be removed from the aquarium.

Mercury chromium

Dosage: 2 to 4 % stock solution

Application: To treat skin wounds after injuries or after scraping off giant cells in a Lymphocystis infection.

Methylene blue

Dosage: 250-400 mg/100 l over a period of 3 days in a treatment vessel

Application: Methylene blue is used to combat parasitic infections such as *Cryptocaryon, Brooklynella, Uronema* etc. However, it is sometimes more effective when combined with copper sulfate or malachite green.

However, due to its toxic effects on nitrifying bacteria, it cannot be used in domestic aquaria.

Methylene blue is sometimes used to combat bacterial infections.

In addition to treatment with malachite green or copper sulfate, for severe parasitic infections, 20- to 30- minute baths are helpful (100-200 mg/5 l).

Metronidazole (Flagyl®)

Dosage: 600-800 mg/100 l over a period of 3 days

Application: For treating marine fish infected by *Hexamita/Spironucleus*.

Metronidazole has no negative effects on nitrifying bacteria or invertebrates. It can be administered with food: 500 mg/100 g of food over a period of 5 to 7 days.

Niclosamide (Mansonil®)

Dosage: 500 mg/100 g of food over a period of 7 to 10 days

Application: To combat worm infections caused by *Nematodes, Cestodes* or *Acanthocephalans*.

Phenoxyethanol

Dosage: 1% stock solution, of which 50 ml/4 l is used to fight *Saprolegnia sp.* (external fungal infections)

Application: The agent can be used to combat *Ichthyosporidium* (internal fungal infection), if food is soaked in 1% stock solution (see also van Duijn).

Piperazine

Dosage: 250 mg/100 g of food over a period of 7 to 10 days

Application: To combat internal digenetic *Trematodes* (Metacercaria), *Nematodes* and sometimes *Acanthocephalans*.

Potassium iodide

Dosage: Although it can be toxic, this is one of the few agents which combat *Lymphocystis* infections.
In addition, infected sites can be brushed with tincture of iodine.

Praziquantel (Droncit®)

Dosage: 200 mg/100 l for 24 hours. Treatment should be repeated after 7 days
250 mg/100 g of food over a period of 7 to 10 days

Application: This agent is used against infections caused by digenetic *Trematodes* (Metacercaria).

Quinacrine (Atabrin®, Mepacrin®)

Dosage: 100-250 mg/100 l over 10 days
Dose must be distributed over several days.

Application: This agent can help combat *Cryptocaryon, Brooklynella,* and *Uronema*, although it can be toxic. After treatment, water, coral, sand etc. may be colored yellow. It can be toxic to invertebrates.

Quinine hydrochloride

Dosage: 1.0-1.5 g/100 l

Application: This drug is recommended by some authors for treating *Cryptocaryon* infections, although results have not been convincing. However, it can be very effective in the treatment of *Cryptocaryon* infections in Catfish, Dwarf Emperorfish, sharks, rays, garibaldis and other species which react to copper sulfate.
It is tolerated well by nitrifying bacteria but not always by invertebrates.

Trichlorfon (Masoten®, Neguvon®, Dylox®)

Dosage: 100 mg/100 l for 2 to 3 days

Application: To combat gill and skin worms, in *Turbellarian* infections and parasitic *Crustaceans* (fish louse and *Lernaeascus sp.*) This drug can be toxic for some fish (e.g., shark, catfish); invertebrates must be removed from the aquarium. During treatment, the fish should be carefully monitored. Water must be changed and an activated carbon filter installed at the first sign of abnormal behavior.

Trypaflavin (Acriflavin®)

Dosage: 1.0 g/100 l over a period of 3 to 5 days

Application: Used against *Amyloodinium* or *Cryptocaryon*.
This drug colors water and decorations. Copper sulfate and formaldehyde — malachite green are equal effective in the treatment of these diseases.

5. Other drug combinations

Antibiotics are not the only drugs that are more effective when used in combinations. Therefore, some combinations of the drugs mentioned above are given here.

Formaldehyde 37 % (1 ml/100 l) — copper sulfate (stock solution 4.0 g/1 l H_2O distilled — 0.25 g of citric acid; of this 25 mg/100 l).

Formaldehyde 37 % (1 ml/100 l) — malachite green (stock solution 5.0 g/1 l H_2O distilled; from this, 1 ml/100 l).

Formaldehyde 37 % (1 ml/100 l) — copper sulfate (see above) — malachite green (see above).

Methylene blue (250-400 mg/100 l) — malachite green (see above)

The combination with methylene blue cannot be used in home aquaria because of the risk of killing nitrifying bacteria.
If necessary, copper sulfate and/or malachite green may be added subsequently.
In general, if bacteria and parasites are to be treated simultaneously, *antibiotics should be combined with antiparasitic agents*. However, combining several drugs may increase toxicity. Furthermore, *copper sulfate should never be combined with neomycin and/or sulfonamides.*

6. Desinfection or sterilization

In some extreme cases, aquaria must be completely disinfected or sterilized. When this is done thoroughly, also biological filter systems must be destroyed so that all potential pathogens are killed.
When tropical marine fish repeatedly contract the same disease, and aquarium inhabitants continue dying or if there are unexplained deaths, sterilization is the only solution. An aquarium can always be re-established – provided you have the patience and motivation!
Live animals should be placed in a quarantine tank, while sand, corals, stones, filter, nets, and pipettes remain in the main aquarium. The aquarium should then be filled to the top with tap water. 35 ml of bleach should be added for every 10 liters of aquarium water. The filter is then left to run for 24 hours; after which you add sodium thiosulfate (3.5 g/10 l) to the water to neutralize chlorine. The water can be allowed to circulate for a few more hours before pumping it off and pouring it away. The entire aquarium including sand, corals, filter, etc. should be washed with normal tap water.

Return everything to the aquarium, reconnect the filter and allow it to operate for 24 hours. This water should then also be poured away before filling the aquarium with fresh saltwater. Then it has to go through the entire nitrogen cycle like a new aquarium. Once this phase has been completed, new fish can be placed in the aquarium.

It's a good idea to be a little self critical, and ask ourselves what might have gone wrong the first time. Mistakes help us to become better aquarists.

Reading list

The reading list is divided into 2 categories:
Category 1 includes books which have a direct application to 'fish diseases and related problems' for the aquarium hobbyist, while
Category 2 consists of works which are scientifical or somewhat advanced for the hobby of keeping tropical marine fish.
This does not mean that these (scientific) works are either uninteresting or incorrect. In fact these are the works that I had available when I was starting to learn about marine aquaria. There are also other works which should form part of this list, but I did not have them at my disposal.

Category 1

BAENSCH, H. (1983): Marine Aquarist Manual, Tetra Press, Germany

BASSLEER, G. (2003): The New illustrated guide to (freshwater) fish diseases, Bassleer Biofish, Westmeerbeek, Belgium

DE GRAAF, F. (1981): Handboek voor het tropisch zeewateraquarium, Publ. Strengholt, Bussum, The Netherlands

DE GRAAF, F. (1973): Marine Aquarium Guide. The Pet Library

DULIN, M. (1976): Diseases of Marine Aquarium Fishes, T.F.H.-Publ., N.J., U.S.A.

GRATZEK, J. and MATTHEWS (1992): Aquariology, the science of fish health management, Tetra Press, Morris Plains, N.J., U.S.A.

HERWIG, N. (1979): Handbook of Drugs and Chemicals used in the treatment of fish diseases, Publ. C. Thoma, Springfield, Ill., U.S.A.

KINGSFORD, E. (1975): Treatment of Exotic Marine Fish Diseases, Palmetto Publ., Fl., U.S.A.

KINGSFORD, E. (1979): Marine Aquarium Compatability Guide, Palmetto Publ., Fl., U.S.A.

KLOCEK, R. (1975): The Marine Primer, Marine Hobbyist News Publ., Ill., U.S.A.

MOE, M. (1982): The Marine Aquarium Handbook - Beginner to Breeder, The Norns Publ., Fl., U.S.A.

QUICK, J. (1977): Marine Disease Primer: Book one, a Guide to Disease Prevention in Aquarium Fishes and invertebrates, Marine Hobbyist News Publ., Ill., U.S.A.

SPOTTE, S. (1973): Marine Aquarium Keeping: the Science, Animals and Art, J. Wiley-Interscience, N.Y., U.S.A.
VALENTI, R. (1974): The Saltwater Aquarium Manual (3° Ed.), Aquarium Stock Co., N.Y., U.S.A.

Category 2

AMLACHER, E. (1970): Textbook of Fish Diseases, T.F.H.-Publ., N.J., U.S.A. - (1981) Taschenbuch der Fischkrankheiten - G. Fischer Verl., Stuttgart, Germany
BULLOCK, G., CONROY, D., en SNIESZKO, S. (1971): Bacterial Diseases of Fishes, T.F.H.-Publ., N.J., U.S.A.
LEWBART, G. (1998): Self-Assessment Color Review of Ornamental Fish, Manson Publ., London, U.K.
NOGA, E. (2000): Fish Disease: diagnosis and treatment, Iowa State Press, U.S.A.
REICHENBACH-KLINKE H. en ELKAN E. (1965): The principal diseases of lower vertebrates., Book 1: Diseases of Fishes, T.F.H.-Publ., N.J., U.S.A.
REICHENBACH-KLINKE H. (1970): Fish Pathology, T.F.H.-Publ., N.J., U.S.A.
SINDERMANN, C. (1970): Principal Diseases of Marine Fish and Shellfish, Academic Press, N.Y., U.S.A.
SINDERMANN, C. (1971): Disease Diagnosis and Control in North American Marine Aquaculture, Elsevier Scientific Publ., N.Y., U.S.A.
SPOTTE, S. (1970): Fish and Invertebrate Culture: Water Management in Closed Systems, J. Wiley-Interscience, N.Y., U.S.A.
SPOTTE, S. (1979): Seawater Aquariums, the Captive Environment, J. Wiley-Interscience, N.Y., U.S.A.
STOSKOPF (1993): Fish Medicine, Saunders Co., PA, U.S.A.
TREVES-BROWN (2000): Applied fish pharmacology, Kluwer Academic Publ., Dordrecht, The Netherlands

Register

Italic figures refer to the illustration number (*Figure*)
The other figures refer to the page number.

An experienced professional presents the principal information about diseases in marine aquarium fish. Presented in a clear, easy-to-understand manner.

Contents include:

- Causes and prevention of diseases in fish.
- Recognizing the symptoms of disease – in practice and under the microscope.
- Drugs and combinations of treatments which even non-specialists can apply.