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THE DISEASES AND INFECTIONS OF SALMONOID FISHES

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by

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The extensive scale upon which certain species of salmon, trout and whitefish are reared in North American hatcheries, and the heavy epidemic mortality from diseases and parasites of various kinds to which the fry and fingerling stages of such fishes are liable, makes the question of the diagnosis and mitigation of such infections one of considerable importance to the fish culturist.

Many of the difficulties which confront the student of this phase of animal pathology in North America are due to the distance which may separate the hatchery official from the laboratory workers, and which make almost impossible a laboratory diagnosis of the disease within a short time of the death of the fish. The material often reaches the laboratory worker in an inadequate state of preservation and unaccompanied by any diagnostic notes made at the hatchery or in the field.

The following notes have therefore been compiled, largely from the scattered literature on the subject, as a guide to the hatchery official, the commercial fisherman and the sportsman in arriving at a preliminary diagnosis of any epidemic disease or infection or any pathological abnormality occurring among salmonoid fishes, and to assist him in accumulating data which will be of value should a more detailed examination be necessary.

METHODS OF DIAGNOSIS

Although the final diagnosis of a fish disease depends upon a careful microscopical examination of the affected tissues, a fairly accurate opinion as to the nature of the disease can often be arrived at from the observation of

the pre-mortem behaviour of the victims, or from the naked eye appearance of the diseased animal or the organs affected.

In an epidemic particularly, notice should be taken of the behaviour of the fishes prior to death; of any movements implying loss of balance, such as when the fish swims in circles or in spirals or floats helplessly belly upwards; of the occurrence of movements suggesting abdominal pain, such as jerky swimming movements accompanied by leaps above the water surface; of any evidence of asphyxiation such as is provided by gaping mouth or distended gill covers. It may be noted that sick fishes tend to isolate themselves from their fellows, to refuse food, to be less responsive to disturbance.

In a fish recently dead, notice should be taken of any unusual emaciation, unusual darkness or lightness of body colour, unusual mucus secretion on skin or gills, slimy or blood stained discharges from the cloaca, the presence on the body surface of raw spots, or boil-like swellings, seed-like nodules, mossy patches or patches of body decay. Any swollen condition of the gills, or the infestation of them by dark brown gill-worms or yellowish "gill-shrimps" should be noted; any unusual features of shape, such as a swollen abdominal region noted also.

When the fish is opened, the body cavity should first be examined for fluid in unusual quantity, or for small tapeworms, or for cysts - whether resembling small transparent bladders or resembling firm cheesy nodules, attached to the peritoneal surface of the viscera or the body cavity.

The colour and consistency of the liver should be observed and a note made as to whether it is normal in appearance, or unusually dark red or unusually pale in colour, whether it is firm or swollen and soft. Observation should be made as to whether the stomach is empty or contains fluid; whether, if empty, it is firm and contracted or loose and flaccid; whether the blood

vessels on the surface of the stomach and intestine are congested, standing out like dark red threads; whether the intestinal wall is semi-transparent or even perforated.

The gut should now be slit open along its whole length, its contents washed out into a shallow dish and search made for flukes, tapeworms or roundworms; the inner surface of the gut should be examined for patches of inflammation and for adherent flukes or worms or protozoan nodules.

If a microscope be available, an examination of smears from the body surface or gills, even with a low power lens, may indicate the presence of parasitic protozoa, flukes or fungi; smears of the intestinal contents or intestinal slime may betray the presence of eggs of flukes, tapeworms or roundworms or even the adult organisms themselves; smears prepared from crushed cysts or nodules may show tapeworm larvae or encysted roundworms or protozoa spores.

When material must be sent some distance for confirmatory diagnosis, it should be packed preferably in ice or sent frozen; bacterial or protozoan diseases are almost impossible to diagnose accurately unless the material is fresh or preserved in ice. If chemical preservation is inevitable, the fish should be soaked for several days in a solution of commercial formalin made up with ten parts of strong formalin to 90 of water or to 90 of 0.75% sodium chloride solution, then sent packed in damp cheese cloth. Organs suspected of harbouring parasites may be packed in the same way. Portions of the body containing tumours or nodules should be soaked in 10% formalin solution for 24 hours, then transferred to 5% formalin solution for 48 hours, then transferred gradually via water, 30% grain alcohol, 50% grain alcohol, into 80% grain alcohol; such tissues should be transferred from the fish to the pre-

servative as soon after death as possible.

The following table of significant features, observable with the naked eye or with an ordinary microscope, and the indications to be drawn from them, is given as an approximate guide towards a preliminary diagnosis of the cause of death or disease. The notes which follow, concerning each disease, may be of assistance in arriving at a confirmatory diagnosis when the resources of a bacteriological or of a zoological laboratory are available.

In the following notes, the North American hatchery designation of the disease of infection is used, but where no such popular name appears to exist, the suffix osis is attached either to the name of the causative organism, as in Schizamoebosis, or to the name of the characteristic lesion produced, as in furunculosis. Strictly speaking, the Greek endings iasis and osis both imply a diseased state, the former ending in oo. In cases, however, where a verb form does not exist, general opinion favours the form osis and for the sake of consistency of nomenclature this ending is employed throughout the present bulletin.

Table of significant features and diseases indicated.

Colour:

1. Unusually dark .....Blindness, gastro-enteritis, liver disease, nephritis, starvation.

2. Unusually light .....Asphyxiation, anaemia, oxygen excess, renal amoebosis.

3. Caudal region conspicuously darker than rest of body .....Staggers.

4. Fins and skin yellowish .....Yellow sickness.

Shape:

1. Fish very emaciated ..... Gastro-enteritis, nodular disease.

2. Emaciated, with large head and attenuated body ("pinheads") ..... Whirling sickness.

3. Swollen abdominal region ..... Peritonitis, hepatic or peritoneal helminthosis.

4. Conical reddish swelling below head in gill region ..... Thyroid tumour.

Mouth and gills:

1. Mouth and gill covers gaping ..... Asphyxiation, renal amoebosis.

2. Mouth gaping, but gill covers normal . Carbon dioxide poisoning.

3. Mouth and gills with tufts of protruding yellow or pink threads .... Chlamydothrix infection.

4. Gills purplish-red in colour ..... Oxygen poverty of medium, blood sucking parasites, paralysis of respiratory muscles through poisoning or following disease infection.

5. Gills unusually pale ..... Anaemia, nutritional disturbance, intestinal worms, lipoid degeneration of liver, gillworm disease, gill shrimp disease, renal amoebosis.

6. Gill filaments congested, with tips swollen, light-coloured, adhering together ..... Gill disease.

7. Gills infested with numerous dark brown flatworms, about one fifth of an inch long ..... Gillworm disease.

8. Gills infested with yellowish gill shrimps each with a long pair of egg sacs ..... Gill shrimp disease.

Eyes:

1. Eyeballs protruding ..... Gas bubble disease (excess of oxygen in medium), pop eye disease, dropsy.

2. Cloudiness of cornea and lens _____ Gas buyble disease.

Body surface:

1. With raw red patches where outer skin has necrosed and been sloughed ..... Dermal catarrh.

2. With large, deep seated smooth swellings which when out exude a creamy pus-like fluid containing large numbers of myxosporidian spores ..... Nodular disease.

3. With boil-like swellings filled with red pus-like material, or with open sores, or (in fingerlings) with irregular dark blotches below skin of lateral region and between dorsal and pelvic fins .....Furunculosis.

4. With white, moss-like patches ..... Dermatomykosis.

5. With ulcerated head region, degeneration of fins and tail, and white mossy patches ..... Salmon disease.

6. With bluish grey slime, especially abundant on dorsal and caudal fins; fins badly frayed or even worn down to stumps; slimy surface infected with oval, transparent worms each with a posterior adhesive disc provided with a pair of recurved hooks and a series of marginal hooks ..... Gyrodactylosis

7. With distinct white line along outer margin of each pectoral fin, accompanied by progressive disintegration of the fins; sores at the bases of the fins filled with glistening white pus ..... Fin rot.

8. With small greyish white blisters containing oval ciliated Protozoa .... Itch disease Ichthyophthirosis.

9. With actively moving ciliated organism resembling circular transparent discs. Cyclochaetosis.

10. With actively moving minute colourless heart-shaped organism; the fish shows a tendency to lie on one side on the bottom of its habitat ..... Chilodontosis.

11. With light bluish or greyish film of mucus containing minute actively moving oval bodies ..... Costosis.

12. With actively moving, round, flattened organisms, one fifth to one half an inch in length ..... Skin louse infection.

13. With numerous yellow or green or brown cylindrical worms, about an inch long, attached by one end ..... Piscicola infection.

Muscles:

1. With bladder-like cysts, between skin and muscles, containing pus and a coiled white worm several inches in length .....Triaenophorus infection.

2. With small white worms between muscle fibres, about 1/4 to 1/2 an inch in length ..... Diphyllobothrium infection.

Body cavity:

1. Distended with fluid ..... Peritonitis; hepatic helminthosis

2. Distended with small tapeworms, 1 to 1/2 inches in length ..... Schistocephalus or Ligula infection.

3. With clusters of threadworms, each about one inch and a half long, swimming in the body cavity fluid ..... Philometra infection.

4. With yellowish cysts attached to the peritoneum in the region of the pyloric caeca or to the peritoneal surface of the stomach and intestine, or with free worms in the body cavity ..... Diphyllobothrium infection.

Kidneys:

1. With small whitish nodules, irregularly distributed in varying numbers increasing with age (up to half a dozen or more), recalling hemp seed, not projecting above the surface, superficially suggesting worm cysts or sporozoan nodules ..... Stannius' bodies, (a normal constituent of the salmonoid kidney.)

2. Kidneys, together with other organs infiltrated with minute white nodules ..... Staggers.

3. With swollen dark grey areas; kidney much firmer than in healthy fishes but easily cut; cut surface smooth and moist, marbles grey ..... Renal amoebosis

4. Kidney substance semi-necrotic and fluid ..... Furunculosis.

Liver:

1. Wholly or partly yellowish grey; pulpy consistency; gall bladder very small and containing a few drops of bright red fluid ..... Fatty degeneration of liver.

2. With small tapeworms, one half to one inch, encysted or free in liver substance ..... Triaenophorus or Ligula infection.

3. Pale in colour; gall bladder abnormally large; red fluid contents with enormous numbers of spore-like bodies..... Yellow sickness.

4. With minute haemorrhage ..... Furunculosis.

Swim bladder:

1. Containing parasitic threadworms up to one inch in length ..... Cystidicolosis.

Stomach:

1. Containing undigested natural food; fish well nourished ..... Sudden death from extrinsic causes; (asphyxiation, poisoning, concussion).

2. Containing undigested food; fish poorly nourished ..... Excess of food following starvation.

3. Stomach empty of food, but with wall contracted, firm, thick. Normal condition.

4. Stomach empty; wall soft and flaccid, although fish freshly caught ..... Stomach disease.

5. Mucosa congested, inflamed, reddened, especially on crests of longitudinal ridges ..... Gastric irritation due to irritant poisons, such as sodium chloride in food.

6. With numerous small reddish worms adhering to inflamed mucosa ..... Enteric distomosis.

7. With numerous threadworms protruding from submucosa, through stomach wall into body cavity..... Dracontiosis.

Intestine:

1. Peritoneal surface reddened; blood vessels congested; rectum blood red; middle third of gut apparently normal, pyloric region with tissues blood saturated, mucosa broken down, muscular layers softened, gut wall glassily transparent, contents blood stained ..... Intestinal inflammation due to uisuitable food, to bacterial infection, furunculosis, whirling sickness, etc.

2. Pyloric region unusually pale and containing tapeworms ..... Enteric cestodosis.

3. Containing threadworms..... Enteric Ascarosis.

4. Intestinal smear showing numerous colourless, minute, pear-shaped, active organisms....Whirling sickness.

5. Smear showing numerous rounded bodies mieroscopic, transparent, with refringent spherical fat globules .... Amoebosis.

6. Smear showing spherical bodies, transparent, marked with concentric ridges ..... Yellow sickness.

Yolk sac of larval fishes:

1. Abnormally enlarged and with bluish tinge ..... Yolk sac or blue sac disease.

2. With opaque white area due to coagulation of the transparent yolk ..... White spot disease.

The classification of salmonoid fish infections.

The infections and diseases to which salmon fishes are liable may be grouped for convenience of description into six classes, namely:-

1. Bacteroses, whose causative organism is a bacterium, usually a bacillus; the more important bacteroses of this group of fishes are Furunculosis, Salmon Disease, Fin Rot, Gill Disease and Skin Spot.

2. Mycoses, whose causative organism is a fungus; the more important mycoses are the dermatomycoses or skin diseases caused by species of Saprolegnia and Achlya and the disease of the central nervous system termed Taumelkrankheit or Staggers.

3. Protozoses, in which the causative organism is a species of Protozoan; the more important infections of this class are the various types of Amoebosis, Costosis, Whirling Sickness, Ichthyophthirosis or Itch, Cyclochaetosis, Chilodontosis, Yellow Sickness and Nodular Disease.

4. Helminthoses, where the infective organism is some species of parasitic worm; the more important infections in this group are Fin Disease, Gillworm Disease, Pop-eye, Cestodosis, Ascaridosis and Cystidicolosis.

5. Arthropodoses, where the organism is a species of parasitic crustacean; the only important infection of this type among salmonoid fishes is an infection of the gills which may be termed Gill Shrimp Disease.

6. Non-parasitic Diseases, a miscellaneous group of diseases, some due to functional disturbance of some organ, others due to metabolic disturbance, others to endocrine deficiencies; the more important of these diseases in salmonoid fishes are Thyroid tumour, Fatty Degeneration of the Liver, Dermal Catarrh, Gas Bubble Disease, Dropsy, Gastro-enteritis, Anaemia and Yolk-sac Disease.

To characterise all such infections as diseases is not strictly speaking correct, for in many cases of parasitic infection no apparent tissue lesions nor any disturbance of the physiological routine of the body seem to be induced by the presence of the parasite.

It must be emphasised, however, that very little is known as to the pathological influence of the parasites upon their hosts, and many parasites apparently harmless to the adult stage of their host may be notoriously inimical to the immature stages, or may lay dormant, and for reasons not yet clearly elucidated, suddenly increase in numbers and virulence and provoke epidemic mortality; every parasitic infection therefore of the fish should be regarded as potentially capable of inducing disease.

In the brief notes which follow with regard to these infections, each infection will be discussed in the following sequence;- brief description of the infection, causative organism, host symptoms, post mortem indications, mode of infection, remedial measures and references.

BACTEROSES

There would appear to be among freshwater fishes and among amphibia, according to Williamson (1929), three types of bacterial infection, namely:-

1. Bacteraemias, or blood infections, due to the invasion of the blood stream by some species of bacterium present normally as a saprophyte in fresh water. Such bacteraemias are, as a rule, not characterised by any local lesions of the tissues but the infected fish shows some degree of inflammation of the alimentary tract and may show superficial haemorrhage in the skin and between the muscles. Such bacteraemias are rapidly fatal, the blood being invaded by large numbers of bacteria and the tissues and the

blood corpuscles offering very slight resistance. A number of epidemic diseases of this type have at various times been described among carp and perch in Europe under such names as Fish Typhoid, Peste des Eaux douces and so forth. A bacteraemia occasionally observed among salmonoid fishes is caused by the invasion of the blood stream by Pseudomonas fluorescens. A disease common among frogs in North America, termed Red Leg, is of this type, and according to Russell (1898) is caused by Bacillus hydrophilus fuscus.

2. Furunculoses, or bacteraemias accompanied by local lesions usually in the form of boil-like swellings in the sub-cutaneous tissue. Furunculosis of salmonoid fishes is of this type although in many cases of furunculosis the lesions are absent, the disease being in effect a rapid and acutely fatal bacteraemia characterised by a rapid disintegration of the kidney and spleen and by the presence in the blood stream of the causative organism Bacillus salmonicida.

3. Ulcerative skin diseases, usually of a chronic type, due to secondary infection of skin injuries by members of a group of bacteria present normally in water and potentially pathogenic to fish. Bacillus salmonis pestis, the alleged causative organism of Salmon Disease may be merely one of a group of Gram-negative, non-sporing, non-chromogenic bacilli, living normally as saprophytes in water and potentially pathenogenic to fish. Another member may be Bacillus columnaris, described by Davies (1921) as the causative organism of Skin Spot, a disease of North American fresh water fishes similar to Salmon Disease but unaccompanied by secondary fungus infection. The organisms of Fin Rot and Gill Disease in North American fresh waters may also be of this type.

Furunculosis

A bacteraemia of salmonoid fishes characterised by the presence in the blood stream of Bacillus salmonicida, by rapid disintegration of kidney and spleen, and often characterised by boil-like swellings (furunculi) of the sub-cutaneous tissue.

Bacillus salmonicida: short, rod-shaped, 1-4 by 0.8-1 in size, with a tendency to occur in pairs; non-motile, non-sporing; Gram-negative; aerobic and facultatively anaerobic; optimum growth temperature, 20°C.; range of favourable temperatures 5°C - 32°C; optimum reaction for growth, pH. 7.6 - 7.8: pathogenic to frogs, minnows, goldfish, trout; non-pathogenic to guinea-pigs; liquefies gelatine, commencing in 24 hours; ferments glucose and mannite in 24 hours with acid production and some strains produce gas in 2-3 days; poor growth in peptone water and no indol production; agar plate colonies in 24 hours; at 15° - 20°C. a delicate growth of small transparent colonies, circular, raised, slightly brownish in colour, semi-opaque, moist, glistening; brown pigment production under aerobic but not anaerobic conditions. Williamson, 1928).

There are apparently three stages of furunculosis.

1. A preliminary stage or incubation stage in which the invading bacteria are located in the alimentary tract. The enteric stage may persist, the fish either acting as a carrier or dying from absorption of bacterial toxins through the alimentary canal wall, or this stage may pass into a bacteraemia.
2. A bacteraemial stage marked by the presence of the causative bacteria in the blood stream, by inflammation of the alimentary tract, by haemorrhages of the liver surface and swimbladder and by progressive disintegration of

kidney and spleen. This stage may be rapidly fatal to young fishes and the victims may not show therefore the boil-like swellings characteristic of later stages of the disease.

3. A furunculosous stage in which the bacteria form masses in the vascular connective tissue of the dermis; the capillary vessels at the site of each mass are destroyed and blood cells are set free among the tissue debris. The lesion may extend downwards into the underlying muscle layer and upwards to the epidermis forming a boil-like mass containing a red pus-like material consisting of necrotic debris and bacteria. There is no leucocytosis and no tissue reaction.

The enteric type of furunculosis is most difficult to diagnose, since it is difficult to obtain a pure culture of B. salmonicida from the gut contents. The bacteraemial type, however, can be recognised, even in the absence of furunculosis lesions, by the fluid, semi-necrotic condition of the kidney, the appearance of the spleen as a loose blood clot, and by the presence in the blood stream of a bacillus which is non-motile, which liquefies gelatine, and which produces brown pigmented colonies on agar.

In fishes freshly dead, culture material should be taken from the kidney; in fishes several hours dead, the caudal artery is better. The fish is washed first with dilute formalin, then with alcohol, and the site of the preliminary incision seared with a copped spatula. The usual culture medium is Fehlmanns fish extract-agar. To prepare the fish extract, heat one pound of fish muscle in one litre of tap water for two hours, over a steam bath; squeeze through cheese cloth, filter through paper and add tap water sufficient to restore the volume to 1000 cc. Add 1 per cent. of peptone, 0.5 per cent. sodium chloride, and 5 per cent. of glycerine. Heat in streaming steam for

30 minutes. To the sterile bouillon add 5 per cent. of 20 per cent. glucose solution which has been separately sterilized. Determine the reaction of the bouillon and correct to Ph. 7.6. To prepare medium, take 1000 cc. of the bouillon and add a sufficient amount of N/1 N_aOH to correct the reaction of the medium to Ph 8.0. Then add 20 grams of threaded agar, heat in streaming steam for 2 hours or in an autoclave for 30 minutes under 15 lbs. pressure. Let stand overnight in the sterilizer. Take the cylinder of agar from the container, cut off the precipitate and discard it. Melt the clearer portion and prepare Petri plates from it. Sterilize in streaming steam for 2 hours or autoclave for 10 minutes under 15 lbs. pressure. The medium should have a final reaction of Ph. 7.6.

Agar plate cultures show in 24 hours at 15 - 20°C a delicate growth of small transparent colonies, and in 7 days the colonies average 1 mm. in diameter, are circular, raised, slightly brownish in colour, semi-opaque, moist and glistening. The pigment begins to appear in four to six days and then increases until deep coffee colour (Williamson, 1928). Owing to the slow growth of the organism, B. salmonicida is rapidly overgrown by the relatively large rapidly appearing colonies of other saprophytic bacteria should the culture be mixed, so that it is practically impossible to recover B. salmonicida from the intestinal contents or from fish that have been dead longer than a day unless the fish has been ice packed.

In gelatine stab cultures, luquefaction begins in about 24 hours. The mode of liquefaction, however, is not constant for all strains of the bacillus and the funnel of liquefaction does not differ in appearance from that of some other bacteria.

Blake, Williamson and Anderson (1930) have established a compliment fixation test for the identification of Bacillus salmonicida. The antigen consists of bacillary emulsion (two day agar slope culture emulsified in 0.85% saline) of a density equal to Browns Opacity Tube No. 2. The immune serum is prepared by intravenous injections of graded doses of B. salmonicida culture into a rabbit. The compliment is fresh normal serum of guinea pig. The haemolytic system consists of a 3% suspension of washed sheeps red blood corpuscles in normal saline solution sensitized with seven M.H.D. (minimum haemolytic doses) of the appropriate haemolytic immune body.

In the test the immune serum is heated at 65°C. for 30 minutes and the compliment is treated with charcoal to exclude fixation effects with other organisms, due to the presence in these sera of natural compliment-fixing antibodies. Strains of organisms other than B. salmonicida are non-reactive with "immune serum".

The mode of infection of salmonoid fishes by the causative organism of furunculosis is not known with certainty. According to Plehn (1924) infection takes place via the alimentary canal. Williamson (1928), however, doubts the occurrence of B. salmonicida as a normal saprophyte in water. The disease is not peculiar to hatcheries but is comparatively common in natural salmon waters. All salmonoids appear to be susceptible but some show less susceptibility than others, Salvelinus fontinalis for example appearing to be more susceptible than species of Salmo. Old fishes appear more susceptible than younger ones, but serious epidemics may occur among fingerling fishes.

No remedial measures are known. The disease is more characteristic of warm stagnant waters than in cold running streams, and especially is liable to occur in waters polluted with industrial by-products.

References:

Plehn (1924); Williamson (1928, 1929); Davis (1929); Mettam (1914); Williamson, Blake and Anderson (1930).

Salmon Disease

An ulcerative skin disease of salmonoid fishes due to secondary infection of abraded skin areas by a pathogenic bacillus and accompanied by fungoid infection.

The causative organism according to Hume Patterson (1903) is Bacillus salmonis pestis, a gelatin-liquefying bacillus which is Gram-negative, non-sporing, actively motile, and productive of a cream coloured growth on agar.

According to Williamson (1929) this organism is only one of a group of saprophytic water bacilli potentially pathogenic to fish, especially when the resistance of the fish is lowered.

The host symptoms comprise an ulcerated condition of the head, back and tail, accompanied by a grwoth of fungus (Saprolegnia). The fish is sluggish, floats near the surface with the fins exposed, and may float with the head so low that the caudal fin is exposed above water.

In post mortem appearance the internal organs are normal; the intestines are empty; bacteria are present in smears from the heart, liver and eggs. Skin preparations, whether teased preparations or sections, show the presence of bacteria and Saprolegnia.

No direct treatment is possible. Diseased fishes should be promptly removed and burned.

References: Patterson (1903); Harrison (1917); Huntsman (1917); Williamson (1929).

Skin Spot

A skin disease characterised by conspicuous dirty white or yellowish areas on some part of the body, which rapidly increase in area, and are accompanied by a progressive weakening of the fish, and by death in one to three days after the first appearance of the lesions.

The disease was first recorded by Davis (1922) at the United States Fisheries Station, Fairport, Iowa, among various freshwater fishes including Salvelinus.

The causative organism according to Davis (1922) is Bacillus columnaris, a long, slender rod-shaped organism, 5 - 12 by 0.5 in size, transparent, homogeneous, slightly granular in structure; motile, chain forming, apt to form column-like masses on the edge of a piece of tissue under cover-glass pressure; reading stainable with Fuchsin or Giemsa; non-sporing; all attempts to cultivate the organism artificially have been unsuccessful.

The host symptoms are the characteristic dirty white or yellow spots which commence usually on the caudal fins and spread rapidly over the rest of the body surface; in late stages of the disease the lesions may cover one half to two thirds of the body, the fins become badly frayed, the caudal fin may become worn to a mere stub. The lesions have each a dark blue centre overlaid by a white veil or cloudiness; surrounding this is a zone of hyperaemia, reddish tinged, about 5 mm. wide. In the last stages the lesions are confluent.

Post mortem examination shows the bacterial growth confined to the skin and gills. The skin is destroyed until the underlying muscles are exposed. The lesions are covered by a thick mat of bacterial growth.

Infection probably follows injury to the skin, such as may be provoked by human handling but fishes with uninjured skins when of low vitality may become attacked. It is a warm weather disease, favoured by warmth and by water foulness.

Prevention of the disease depends upon care being taken when handling fish.

Treatment consists of removing infected individuals and destroying them. Fish that have to be handled should be immersed after handling in a bath of 1 in 1000 solution of copper sulphate for one to two minutes.

References: Davis (1922).

Fin Rot

A bacterial infection of the dorsal and pectoral fins, bringing about complete disintegration; the cause of heavy losses in trout hatcheries in the north eastern United States.

The causative organism has not been isolated but is believed to be a long rod-shaped bacterium.

Host symptoms: the commencement of the disease is marked by the appearance of a distinct white line along the outer margin of the dorsal fins, or, in fingerlings, of the pectoral fins. The white line gradually moves towards the base of the fin leaving the marginal area of the fin badly frayed. The entire fin may be destroyed and sores filled with glistening white pus may develop at the base of the fin.

A post mortem examination shows bacterial infiltration of the skin, the sub-cutaneous tissue and the superficial muscles.

The mode of infection is probably through contact between fishes.

The treatment consists of immersing the infected fish in a solution of 1 part copper sulphate in 2000 of water for one minute, followed by removal to running water.

References: Higgins (1928); Davis (1929).

Gill Disease

A bacterial infection of the gills of salmon and trout fingerlings, first recorded by David (1926) in Vermont, but probably prevalent throughout North America.

Causative organism: a bacillus; rod-shaped, chain forming, colourless, transparent, covering the gill surface.

Host symptoms: no definite symptoms beyond the gill changes; the gill filaments are swollen, their tips enlarged, becoming adherent. Secondary fungoid infection may occur.

Treatment: immersion in 1:2000 solution of copper sulphate for one minute followed by rapid transference to running water.

References: Davis (1926).

Mycoses

The pathogenicity of fungi to the tissues of fishes has been studied only slightly. Up to the present the only fungal diseases of fishes that have been described are certain skin infections associated with the presence of species of Saprolegnia and Achlya of the oomycetous family Saprolegniaceae, and an infection of the internal organs, by Ichthyophonus hoferi, a phycomycetous fungus.

Saprolegnosis

A dermatomycosis of skin, gills, fins, eyes; probably a secondary infection of abraded regions of the epidermis in fishes living under natural conditions but possibly a primary infection among fishes crowded in warm stagnant hatchery waters.

The causative organism is a species of Saprolegnia or of Achlya. Identification of the species or even of the genus depends upon the structure and arrangement of the sexual organs and is thus a task for a trained mycologist.

The host symptoms comprise chiefly the appearance of felt-like patches of filaments; about one third of an inch in depth, on the body surface. The patches spread over the body with great rapidity and may penetrate downwards through the epidermis to the dermis and even to the underlying muscles. Invasion of the gills and blocking of the blood vessels in the gills by hyphal ingrowth, brings about the death of the fish.

Treatment consists in brushing the body with a soft brush dipped in 1:1000 solution of potassium permanganate, and then immersing the fish for 30 minutes in 1:100,000 solution of the same compound. Fish should not be crowded, 2 gallons of fluid per pound weight of fishes being the usual allowance. (Plehn, 1924).

Other remedies comprise immersion for one minute in 1:2000 solution of copper sulphate or immersion until distressed in 3% solution of sodium chloride (Davis 1929); immersion for 3 seconds in methyl alcohol solution, 30 drops per quart of water, or immersion overnight in mercurochrome, 10 drops of 2 1/2% solution per quart of water;.

Predisposing causes towards infection are intestinal disease, post-spawning exhaustion, starvation, ectoparasites, abrasion of the skin by chilling, by chemical pollution or by human handling.

References: Plehn (1924); Davis (1929); Mellom ( ).

Staggers

An infection of salmonoid fishes in Europe, where it is termed Taumelkrankheit, recorded in North America only by Ellis (1930) in Pseudopleuronectes americanus at Halifax, Nova Scotia.

The causative organism is Ichthyophonus hoferi. Plehn and Mulson, of the class Phycomycetes, order Chytridiales. It is present in smears made from the internal organs, as small spherican cysts, 150 μ in diameter according to Ellis (1930). Within each cyst is a protoplasmic multinuclear mass. The mass may protrude through the cyst wall as long amoeboid pseudopodia.

The host symptoms may consist of characteristic "weaving movements" of the infected fish, as if the sense of balance were affected. This characteristic behaviour, however, may not be shown if the central nervous system has not been invaded.

Post mortem examination may show the heart to be abnormally enlarged in early stages but shrunken to half in later stages; it feels hard and gritty and cut surfaces appear as if sprinkled with grit. Other organs may show similar infiltration with tiny white grit-like nodules. The nodules occur usually in all the internal organs of the body but the bones, eyes and skin are usually free. Ellis in Pseudopleuronectes found large creamy white masses approximately 5 cms. in diameter, adhering in the body cavity to the peritoneum. Smears from such masses showed the characteristic cysts.

The mode of infection is unknown but experimentally feeding with the organs of an infected trout provoked disease in an uninfected animal. The organisms apparently wander through the gastric mucosa into the blood stream, appearing there after 3 - 4 days as numerous minute spheres 5 - 10 μ in diameter. From the blood they invade the tissues, increasing in size up to 100 μ and then encyst.

In view of the prevalence of this or similar organisms in marine fishes, especially Gadidae and Pleuronectidae, the use of marine fish meal as a food for hatchery salmonids is not to be recommended.

References: Plehn (1924); Ellis (1930).

Protozoses

The protozoal organisms which infect fishes are drawn from at least six of the seven accepted classes of Protozoa. To the Rhizopoda belong Schizamoeba salmonis and probably others, as yet unrecorded, amoebic parasites of fishes; the Mastigophora include Costia - the causative organism of a severe type of dermatitis - and Hexamita, an intestinal parasite; the Cnidosporidia include one order - the Myxosporidia - almost exclusively parasitic in fishes; the Sporozoa, so far as present knowledge goes, are represented in fishes only by the Haemogregarina, intracorpuscular parasites of the blood; the Opalinata are represented only by Protopalina saturnalis in the marine fish Box boops; the Ciliata are represented by Ichthyophthirius, Chilodon, Cyclochaeta, the organism associated with severe skin diseases; the Suctoria are unrepresented among fish parasites.

Gastric amoebosis

An infection of the alimentary tract of salmonoid fishes, recorded in the United States from Salmo shasta, Salvelinus fontinalis, Salmo fario. The cysts of the infecting organism occur plentifully in the intestine and have been recorded from Oncorhynchus tschawytscha and O. kisutch in Pacific coast hatcheries and from trout in New York hatcheries. Although the infecting organism is present usually in large numbers there is as yet no evidence that it is pathogenic to the fish.

The infecting organism is Schizamoeba salmonis, Davis, a colourless, very transparent amoeba abundant in the mucus which covers the stomach epithelium, and varying in size from 10 - 25 μ. The organism shows practically no amoeboid movement and there is not a demarcated clear ectoplasm such as occurs in other amoebae, nor any contractile vacuole, glycogen inclusions, nor food particles.

The nucleus is usually single but multinucleate forms occur. The nucleus is vesicular, without a karyosome, the chromatin being arranged around the nuclear wall.

The cysts are spherical, 15 - 35 μ in diameter, with a thin transparent wall and a cytoplasm with numerous refringent spherical bodies, apparently fat globules; glycogen is probably present in the cytoplasm in a diffused condition. The cysts are multinucleate, having three or four nuclei each with a large, deeply staining, central karyosome connected to the nuclear membrane at one point by an achromatic structure containing numerous imbedded chromatin granules. Each cyst is capable of dividing into 4 - 11 daughter cells.

The mode of host infection is probably by ingestion of cysts voided by an infected fish.

References: Davis (1926); Kudo (1931).

Renal amoebosis

An epidemic disease of yearling Brook Trout and Rainbow Trout in Europe and probably in North America, sometimes causing heavy losses.

The causative organism is an undescribed parasitic amoeba, first recorded by Hofer. The host symptoms are somewhat indefinite. The infected fish is unusually susceptible to oxygen deficiency and does not stand shipment well. The colouring is exceptionally bright, the body swollen, the eyes somewhat protruding and dark coloured with the cornea and lens cloudy; the fish may show partial blindness; death occurring frequently in the exhaustion position, with mouth and gill covers gaping.

In post mortem appearance the gills are unusually pale, the gut empty, the body cavity dropsical, the eyes sunk into their sockets. The internal organs appear normal except in the case of the kidneys which are quite abnormal in appearance and show dove-grey, swollen patches; the black pigment characteristic of the trout kidney may have disappeared completely; the kidney is firmer than in a normal fish but is easily cut, the cut surface appearing smooth, moist, marbled grey.

Microscopical examination of the kidney will show extensive compression and overgrowth of the uriniferous tubules by interstitial tissue in which numerous minute organisms not exceeding 20μ in diameter are present; the organisms apparently induce inflammation of the lymphoid tissue and occasionally attack the tubules themselves; the suppression of kidney activity induces general dropsy and eventually by death.

References: Plehn (1924).

Costosis

A dermatitis of freshwater fishes.

The infecting organism is Costia necatrix, Henneguy, a mastigophoren protozoan of the order Protomonadida. It is 10 - 20 μ by 5 - 10 μ in size, flattened and pear-shaped, with a funnel-like depression at the pointed end from the bottom of which arise two long flagella extending beyond the body and serving to attach the parasite to the fish, and two short flagella which are confined to the interior of the funnel. There is a spherical nucleus at the middle of the body and a contractile vacuole behind this. Reproduction is by longitudinal division. The cysts are spherical, 7 - 10 μ in diameter.

The host symptoms comprise the presence of a light bluish or grayish film over the body and fins, accompanied by a loss of appetite, and by exhaustion and eventually death. The post mortem diagnosis depends upon recognition of the parasite in smears of the skin mucus.

Control measures consist of immersion of the fish in 3% sodium chloride solution for 10 minutes, repeated three times, at intervals of three days; or immersion in 1:5000 glacial acetic acid solution for one minute.

References: Wenyon (1926); Davis (1929); Moore (1923); Plehn (1924); Kudo (1931).

Hexamitosis or Whirling Sickness

An intestinal infection especially of fingerling trout in North American hatcheries occurring either as a chronic wasting disease or as an acute enteritis.

The causative organism is Octomitus salmonis, Moore, possibly identical with Octomitus intestinalis truttae of European salmonids, a mastigophoran protozoan of the order Polymastigida. It is 10 - 12 μ by 6 - 8 μ in size, pear-

shaped, with eight anteriorly directed flagella, two arising from the posterior end of the body. The animal is active and rotates rapidly on its longitudinal axis. A pair of slender, internal longitudinal flexible rods is usually visible in the living animal. There is a pair of ovoid nuclei at the anterior end of the body each of which shows a central elongated karyosome which stains deeply with haematoxylin. Reproduction is by a process of binary fission. The cysts are ovoid, transparent, 7/7 to 10 μ in size and stain deeply with iodine.

The host symptoms are somewhat indefinite as no external lesions appear. The chronic form of the disease is characterised by the emaciated or "pin head" appearance of the fish and by the unusually dark colouration. The acute form of the infection is characterised by the fish performing whirling or corkscrew movements, and by distension of the gill covers.

Post mortem examination shows the intestinal wall to be yellowish white and translucent, and the intestine to be distended with watery fluid. In the chronic phase this fluid contains numerous Hexamitas, but in the acute phase the parasites are lodged within the gut epithelium.

Infection is undoubtedly by ingestion of cysts. Older fish were formerly regarded as unaffected by infection but according to Moore (1924) infection may induce marked disintegration of the testes, leading to actual obliteration of the spermatogenous tissue. Fingerling fish suffer from the chronic wasting type of infection when the parasites are in the gut lumen, or from the acute intestinal inflammatory type when the parasites invade the gut epithelium. Such invasion is apparently stimulated by rise in temperature of the external medium, by oxygen deficiency, by cessation of feeding.

Control measures are impracticable so far as elimination of the parasite from the infected hatchery is concerned; overcrowding, oxygen deficiency, im-

proper food, must be avoided. Fish in transportation must be kept at a temperature of 40 - 45°F and given an abundant supply of oxygen.

References: Wenyon (1926); Moore (1923); Davis (1925); Kudo (1931).

Ichthyophthirosis

A pustular eruption of the skin of various species of freshwater fishes, usually termed "itch disease"; a common infection in overcrowded hatcheries in Europe and North America.

Causative organism: Ichthyophthirius multifiliis, Fouquet 1876, a protozoan of the order Holotrichida, class Ciliata. The organism is egg-shaped, 300 - 800 μ long, the body uniformly covered with longitudinal rows of cilia. At the narrow end, a small cytostome leads into a short oesophagus. Numerous superficial contractile vacuoles are present. The nucleus is large and horseshoe shaped. Reproduction is by multiple fission within a gelatinous cyst; 100 - 1000 daughter organisms are produced each 30 - 50 μ long, each with a single contractile vacuole, an ovoid macronucleus and a small spherical micronucleus.

Host symptoms: appearance of greyish white pustules on the body surface. Each pustule contains a single organism and represents an area of epidermis eaten away by the embedded parasite. In late stages of infection, so called "Scalded areas" or areas of Saprolegnia may follow. The fish is unusually slimy, refuses food and eventually dies in a few weeks after initial infection from asphyxia induced by infection of the gills by the parasite.

The fish becomes infected from daughter ciliates emerging from a cyst. Each young ciliate burrows into the host epidermis, especially attacking unscaled areas or the gills. The parasite grows rapidly and in 5 days (65 - 75°F) to 30 days (35 - 40°F) is fully grown, whereupon it leaves the host, drops to

the bottom of the tank, encysts and undergoes multiple division.

Treatment: (a) immersion of each fish in a solution of 5 drops of 2% mercurochrome per gallon of water for 5 days, renewing the solution each day (Adams, quoted by Mellen);

(b) immersion in a 5% solution of aluminium sulphate for one minute.

Prophylaxis: (a) retention of fish in rapidly running water so that the parasites when leaving the fish will be swept away.

(b) retention of temperature of the tank below 48°F.

(c) disinfection of infected tanks with 10% solution of lime.

References: Guberlet (1926); Prytherch (1924); Barthelemy (1926); Mellen (1928); Wenyon (1924); Davis (1929); Kudo (1931).

Chilodontosis and Cyclochaetosis

Skin diseases of freshwater fishes.

Causative organisms: Chilodon cyprini or Cyclochaete Domerguei. Chilodon cyprini (Moroff, 1902) is a protozoan belonging to the Order Holotrichida of the class Ciliata. The organism is a dish-shaped, convex dorsally, flat ventrally, 50 - 70 μ in length by 30 - 40 μ in breadth; the general outline is kidney-shaped, with the anterior edge broader than the posterior; the anterior margin forms a thin lip which passes along the convex left margin of the body and loses itself near the posterior end; cilia occur over the whole ventral surface and on the margin of the dorsal surface. An anterior ventral cytostome leads into a straight or slightly curved oesophagus supported by longitudinal bars representing thickenings of the cytoplasm. There is an ovoid macronucleus and a small micronucleus. Two contractile vacuoles are present, one on either side of the macronucleus.

The encysted organism is spherical. Reproduction occurs by transverse fission, preceded by a process of conjugation (v. Wenyon, 1926).

Cyclochaete Domerguei (Wall) belongs to the order Peritrichida, but unlike most of the members of this order is unstalked. The organism is disk-shaped, about 100 μ in diameter and about 25 μ in thickness. The surface in contact with the host has a shallow depression which functions like a vacuum cup to attach the organism to the host skin; within this so-called acetabulum is a ring of 28 - 32 hooks; external to these hooks, the rim of the acetabulum is provided with a zone of locomotor cilia. The mouth is situated on the disc margin and from it a short gullet extends into the organism. Below the mouth, a ring of sensory cilia or "cirri" surrounds the disk. There is usually one contractile vacuole, and a crescent-shaped macronucleus. Reproduction is by simple fission.

Host symptoms: similar in both types of infection; patches of silvery, glossy scum appear on the skin of the fish; the patches become confluent until the whole skin and gills are covered; haemorrhagic patches may appear below the patches; the fish shows increasing signs of slow asphyxiation and eventually dies therefrom.

Treatment: immersion of the fish in 2 - 2 1/2% solution sodium chloride for 20 - 30 minutes, repeated; or in 0.15% solution of acetic acid for one minute. Disinfection of troughs, tanks, etc. with 2 1/2% formalin.

References: Guberlet (1926); Wenyon (1926); Mellen (1928); Van Roekel (1929); Kudo (1931).

Nodular disease

A subcutaneous or intermuscular infection with certain species of Myxosporidian Protozoa.

Causative organism: some species of Henneguya or Myxobolus or other genera of Myxosporidia.

It is essential in the diagnosis of a myxosporidian infection that recognition be paid to the fact that the organism may occur either as a mobile trophozoite or as a spore. The trophozoite is a feebly mobile stage, actively moving by means of well developed pseudopodia in amoeba-like fashion. Such free forms, however, are usually found only in the urinary bladder or gall bladder. In the tissues, such as in the case of Nodular disease, the trophozoite stage is represented by spherical or oval cysts filled usually with a creamy pus-like fluid containing spores. The spore is derived by a complicated processof sporulation from the trophozoite stage or the cyst; the spore is enclosed in a shell of two valves, meeting each other in a straight or S-shaped suture; the shape of the shell varies in different genera and is a valuable systematic character. Within this spore is a mass of protoplasm usually termed the sporoplasm, granular in structure, with one or two nuclei and with a vacuole whose contents stain deeply with iodine, as if containing glycogen. Within the spore also is a pair of spherical or pear-shaped polar capsules each containing a coiled filament which can be extruded from the spore when the latter is stimulated by the alimentary enzymes of the host.

A fish is infected by ingestion of spores. In the gut of the fish the spore opens and liberates the sporoplasm which makes its way by amoeboid movements to its final location in the host.

The following organisms have been recorded as causing nodular disease

in salmonoid fishes.

Henneguya salmincola (Ward).

Habitat: sub-dermal tissues of Oncorhynchus keta and Oncorhynchus kisutch. The infection is characterised by conspicuous cysts in the muscles between the sub-peritoneal and sub-cutaneous tissues. Trophozoite in the form of opaque cysts, whitish, pyriform, 3 - 6 m.m. in diameter; cysts covered by numerous layers of connective tissue forming a tough membrane around the parasite. The cyst contains numerous spores in various stages of development. Spore: oval, with rounded anterior attenuated posterior end; elliptical in profile; valves smooth, sutual edge with 6 or 7 undulations; tail double, composed of two fine, equal prolongations of the shell valves running roughly parralel to one another. Polar capsules pyriform; coiled filament indistinct; sporoplasm finely granular with large iodonophilous vacuole. Spore dimensions, length 42.75 - 52.44μ, bread averaging 8μ, thickness 4.78μ, tail 35μ long, polar capsule 3.7 - 4.5μ by 1.59 - 2.85μ.

Henneguya zschokkei (Gurley).

Habitat: sub-cutaneous and intermuscular tissues of species of Coregonus in Europe.

Trophozoite: in form of rounded or oval cysts surrounded by compact membrane with many nuclei; largest cyst 32 mm. by 16 mm. Sporoplasm granular. Numerous spores.

Spores: rounded oval in surface view, broadly elliptical in lateral view; anterior end rounded, posterior end tapering to form a tail. Suture distinct. Tail single or bifurcated. Length of spore 55μ, body 10 by 7μ, tail 4 - 5 times body length; polar filament 6 - 10 times spore length.

Henneguya nusslini (Schubert et Schroder).

Habitat: sub-cutaneous tissue at base of dorsal fin of Salmo fario. Trophozoite: in form of lenticular cysts, 1.5 - 2 mm. in diameter surrounded by many concentric layers of fibrous tissue. Spore: broad, oval, flattened; anterior end rounded, posterior end with tail; shell thick, often showing sutural ridge; tail bifurcated. Sporoplasm in posterior half of spore with prolongation between polar capsules, uniformly granular, with iodinophilous vacuole and one or two nuclei. Polar capsules pyriform, opening independently; polar filament coiled 6 - 7 times. Spore length 12μ excluding tail, tail 20μ; breadth 8 - 9μ; polar capsules 5μ by 3μ; filament 4 - 5 times spore length, excluding tail.

Treatment: no treatment is known for nodular infections; such infections, however, are pathogenic only when very intense. Fish showing such infections, however, should be exterminated. No curative measures are known as the thick spore shell protects the organism against the influence of chemical baths.

References: Kudo (1919); Plehn (1924); Ward (1920); Davis (1917); Hahn (1913); Kudo (1930).

Yellow sickness

An infection of the gall bladder and intestine with species of Chloromyxum.

Causative organism: Chloromyxum truttae or Chloromyxum thymalli.

Chloromyxum truttae

Habitat: gall bladder and bile ducts of Salmo fario (France) and Salvelinus fontinalis (N. America). Trophozoite: amoeboid, elongated resembling Amoeba limax, about 40μ in length; rounded or irregularly contoured with small

pseudopodia (Davis, 1929, refers to the American form as having a single lobe-shaped pseudopodium); cytoplasm clear, colourless; movements very active and continuing after death of host; broad and obtuse pseudopodia well developed at the anterior end of the body. Nuclei numerous. Spores: spherical four polar capsules of different size; shell valves marked with parallel ridges. Dimensions 8 - 9μ in diameter.

Symptoms and diagnosis: yellowish colour of skin and fins of living fish; intestinal smear showing characteristic spores.

Remedies: no remedial measures are known, but so far as is known the effect of the infection on the fish is negligible.

References: Kudo (1919); Davis (1929).

Drehkrankheit or Twist Disease

An infection of the cartilaginous skeleton, particularly in the skull, by trophozoites of Lentospora cerebralis.

Causative organism: Lentospora cerebralis (Plehn).

Habitat: cartilage and perichondrium of Salmo irideus, Salvelinus fontinalis, Salmo salar.

Trophozoite: amoeboid, greatly varying in size; small forms probably develop into large individuals with 50 or more ring-like nuclei.

Spores: circular in superficial view, lenticular in lateral view; shell smooth; sutural ridge distinctly thickened; polar capsules two, pyriform, convergent, usually equal in size. Extruded polar filaments crossing each other. Sporoplasm with two ring-like nuclei but without iodinophilous vacuole. Dimensions: diameter 6 - 10μ, polar capsule 2/5 length of spore, polar filaments 40 - 50μ.

Symptoms: a disease of young fishes, the first indication being provided by certain peculiar movements of the victim, owing to the presence of the parasite in the cartilage of the auditory capsule. The sense of balance is affected. The fish turns convulsively in circles, continually to the right or left, twists round so as to display the white colouration of the ventral surface, leaps convulsively out of the water, sinks exhausted to the bottom of the tank and lies there breathing rapidly. A period of apparent recovery is followed by another attack, and so the disease goes on for days or weeks according to the constitutional resistance of the victim. Very young fishes withstand the disease badly but older fishes are more resistant and should the epidemic commence in late summer very few fishes may show the symptoms and the presence of the disease in the hatchery may pass unnoticed. In the following year or year but one, however, the disease may break out in severe epidemic form. A second symptom of the disease is a darkening in colour of the tail region. The contrast between the dark tail and the normal light colouration of the body disappears however soon after death.

Post mortem diagnosis: the organism appears first within the cartilaginous auditory capsule, invading from there the lymph spaces. The cartilaginous tissue becomes gradually destroyed by the amoeboid trophozoites but these cannot be recognised with certainty in fresh material and even in sections of preserved material are not easy to recognize. In late stages of the disease, however, when spores are present, observation of fresh material provides accurate diagnosis. Remove the skin of the head, behind the orbit and slice away the auditory capsule so as to expose the semicircular canals. Tease up on a slide a portion of the cartilage of the capsule and verify microscopically the presence of spores.

The upper end of the jaw muscles are attached to the skull in the neighbourhood of the auditory organ. When, therefore, the mouth is opened the diseased organ is irritated, the balance is affected, and the attack of vertigo follows.

Fishes attacked in early summer are very susceptible because the cartilage is too soft to oppose the parasite. In late summer the cartilage is harder so that the progress of the disease is slower. Danger from infection in autumn is not dangerous. In an early infection, however, the organism continues to destroy the cartilage and spread from the capsule to the rest of the skull. Destruction of the jaw articulation prevents the mouth from being closed and produces a deformation of the head. Invasion of the vertebral column involves the sympathetic nervous system and brings about the dark colouration of the caudal region. Direct danger to life in the infected fish is not usual in a late infection but the survivors may be more or less crippled, may show arrest of growth, and may have great difficulty in feeding.

Mode of infection: there is some suggestion that the initial infection of a hatchery is brought about by the use of marine fish meal as a food, Lentospora occurring in species of Gadidae, and that infection of the hatchery may continue over a period of years, the spores lying dormant in the mud at the bottom of the rearing ponds. The only remedy would seem to be the drainage and thorough disinfection of infected ponds.

References: Plehn (1924); Kudo (1931).

Helminthoses

Although fishes are liable to external infection by leeches and certain flatworm species, and to internal infection by flatworms, roundworms and thorn-headed worms, such infections do not necessarily induce tissue lesions or metabolic disturbances in diseases. Nevertheless the term helminthosis is convenient as a designation for a mass ~~of~~ infection of an animal by some type of parasitic worm, whether Flatworm, Roundworm or Annelid Worm.

The Platyhelmia or Flatworms include two orders exclusively parasitic upon animals - the flukes or Trematoda, and the tapeworms or Cestoda - and many species of these orders attack fishes. Flukes are small, flattened, leaf-shaped worms occurring on the gills, skin, or within the alimentary tract of animals, adhering to the tissue of the host by means of one or more muscular cups or acetabula which function like vacuum cups.

The tapeworms on the other hand, are flattened, ribbon-like organisms, from a fraction of an inch to several feet in length, occurring as immature stages in the alimentary tract, muscles, connective tissue or body cavity of the host, but occurring when ~~connective-tissue-or~~ adult only in the alimentary tract; they adhere to the host tissue, when adult by an organ of adhesion termed the scolex which has two or four slit-like or even cup-like depressions or bothria and may have in addition a number of hooks.

The Nematoda or Roundworms are well represented in fishes usually as smooth, thread-like tapering forms in the alimentary tract, or as watch-spring-like, coiled immature forms between the muscles, in the liver, or elsewhere. The Acanthocephala or Thorn-headed worms are intestinal forms, short, cylindrical, thick, with a protrusible proboscis armed with rows of hooks by which they bore into and adhere to the lining of the host gut.

The Annelida or Segmented Worms are represented among fish parasites by certain species of Hirudinea or leeches, segmented, somewhat flattened or cylindrical worms adherent to the skin of the fish by means of cup-like acetabulum at either end of the body, and feeding upon the blood flowing from an incision made by three triangular blade-like jaws.

The following infections are the principal helminthoses recorded up to now from salmonoid fishes.

Fin Disease (Gyrodactylosis)

A contagious infection of the skin and fins of freshwater fishes in Europe and North America by ectoparasitic species of the trematode family Gyrodactylidae.

Gyrodactylid flukes are flukes of small size, less than a millimeter in length, flattened, leaf-shaped; the anterior end has two or more contractile processes; the posterior end has a flattened, heart-shaped adhesive organ whose edge is divided into 14-16 lobes each provided with a small hook, and whose ventral surface has a pair of large curved hooks.

There are three genera which may be distinguished as follows, the key being modified from Plehn (1924):-

1. Adhesive organs with two large central hooks:

a. 2 anterior processes and 16 marginal hooks, eyes lacking .....Gyrodactylus

b. 4 anterior processes and 14 marginal hooks, 2 pairs of eyes ...Dactylogyrus

2. Adhesive organ with 4 large central hooks, 2 pairs of eyes ..... Ancyrocephalus.

Symptoms: uneasy behaviour of infected fishes which have a tendency to rub their bodies against the sides of the tank, the fins show fraying at the

edges, the rays projecting even as spines, or may even be reduced to mere stubs. The bases of the fins become ulcerated; a bluish gray slime may cover the infected skin surface. Diagnosis depends upon recognition of the organisms which are embedded in the mucus which covers the fish surface.

Infection results from contact with an infected fish.

Treatment is difficult as the worms are embedded in the skin mucus. Guberlet (1927) from a series of experiments claims the most effective treatment to be the use of 4 1/2 - 5% sodium chloride solution in which the fishes - in this case fingerlings of Salmo irideus shasta - were immersed for a period of 1 1/2 - 2 1/2 minutes, after which they were transferred to a rapidly flowing water; one treatment is usually sufficient but a second bath may be necessary.

Mellen ( ) quoting a number of authorities gives the following list of immersion fluids:

glacial acetic acid, 1:500, for 40-60 seconds; formaldehyde, 30 cc. of 10% solution to 10 gallons of water, for 8 - 15 minutes; 0.1 - 0.2% acetic acid, for 1/2 - 1 minute; 0.05% sulphuric acid for 15 seconds; 0.2% glacial acetic acid for 1 minute repeated after 2 weeks; 2 1/2% acetic acid for 10-12 seconds; glacial acetic acid, 1:350-500, for 30-40 seconds; salicylic acid, 1.25: 100,000 for 30 minutes; potassium permanganate, 1:100,000 for 2 or 3 seconds; formaldehyde, 22 cc. 100% solution to 20 gallons of water for 15 days; hydrogen peroxide, 3% solution for one minute; ammonia, 0.05% for 5 - 20 minutes.

Embody (1924) discussing an epidemic of Fin Disease among yearling brook trout in a New Jersey State hatchery, where the mortality jumped from an average of 0.16% per day to 1 per cent. per day, claims as a result of

experiments the following results:

(1) 2 1/4% solution of sodium chloride or 0.5% copper sulphate, for 5 minutes is not effective.

(2) 0.05% sulphuric acid kills the worms instantly and seemed not to injure the fish if the immersion period did not exceed 15 seconds.

(3) 0.2% acetic acid kills the worms in 15 seconds and does not noticeably effect the fingerlings and yearling trout after 2 minutes immersion.

The treatment finally adopted and used on a large scale was the following: a solution containing 0.2% acetic acid was made by adding one part of glacial acetic acid to 495 parts of water. This was contained in a wash tub, a wash tub half filled containing enough liquid to treat 1000 trout 3 - 6 inches long. A dip net with a ring about one foot in diameter and a bag that stretched nearly to the diameter of the tub was used to hold the trout during treatment. From 150 - 200 trout were submerged at one time. The first four lots remained in the liquid for 1 minute; the next three lots for 1 1/2 minutes, and the last three lots remained for 2 minutes; the reason for the variation in the duration of immersion was to allow for the weakening of the acid solution by successive batches of fishes.

Hess (1930) has made an experimental study of the control of external flukes on fishes. He finds marked difference in the tolerance by different species of fishes to chemical treatment. Out of approximately 20 different chemical substances tested on goldfish, the one substance recommended is potassium permanganate. Prolonged treatment with a weak chemical such as this seems preferable to short immersion in acetic acid.

Under aquarium conditions, immersion of 2 hours in a solution of one pound of potassium permanganate in 32000 gallons of water in cement or steel

tanks is recommended. Unfortunately in hatchery ponds potassium permanganate rapidly oxidises and becomes ineffective after 2 hours, and a strength of one pound in 30000 gallons of water will not completely clear a heavy infection. Such a heavy infection is best combated by clearing the pond of fish, and leaving free of fish for nine days in summer, or 3 - 4 weeks in winter; or the pond may be drained completely and sprinkled with hydrated lime, eggs and living flukes in the moist mud being killed within one hour.

References: Plehn (1924); Guberlet (1927); Embody (1924); Hess (1930); Mellen (1928).

Gillworm Disease (Discotylosis)

A gill infection by species of Discocotyle, a common genus of Trematoda on sea fish such as Clupeidae and marine Salmonidae, but uncommon in fresh water. D. sagittatum has been recorded from Rainbow trout in Europe and D. salmonis on Rainbow Trout in North America.

Causative organism: Discocotyle sp.; a trematode similar to Gyrodactylus, but larger, brownish in colour, confined to the gill filaments to which it adheres by means of a posterior adhesive organ which has two rows each of four acetabula each armed with small hooks.

Symptoms: acute anemia and asphyxiation, distended mouth and gills; diagnosis by presence of parasites on gill filaments.

Treatment: acetic acid immersion is uselsss; in Europe immersion in saturated solution of sodium chloride for 1 1/2 minutes is recommended; Laird (1927) in North America recommends Zonite, one part to five of water, sprayed by an atomiser on to the gills of the fish.

References: Plehn (1924); Laird (1927).

Enteric distomosis

Infection of the alimentary tract by distomid Trematoda.

Infective organism: species of Azygiidae and Allocreadiidae, possibly other distomid families.

Distomid flukes possess two acetabula, a terminal "oral acetabulum" and a "ventral acetabulum" situated a short distance from the anterior end.

The following characteristics are modified from Ward and Whipple (1928).

Fam. Azygiidae. Large, powerfully muscular flukes, elongate and flattened; acetabula conspicuous; well developed pharynx; intestinal fork reaching to posterior end of body; excretory bladder Y-shaped, the forks reaching nearly to the oral sucker; genital pore median, anterior to ventral acetabulum; uterus with ascending limb alone, extending from ovary to genital pore in closely laid transverse loops; Laurers Canal present; no receptaculum seminis; vitellaria follicular, lateral, not reaching to posterior end; stomach parasites of fishes.

Genus Azygia. Ovary in front of testes.

Genus Leuceruthrus. Ovary behind testes.

A. lucii. (Mull.) is recorded as occurring in masses in the stomach of Salmo salar in Europe; A. sebago is recorded in North America from Salmo salar sebago.

Fam. Allocreadiidae. Small distomes with a somewhat drawn out body, mobile anteriorly; acetabula well developed; intestinal forks long but not reaching posterior end; pharynx and oesophagus present; genital pore near ventral acetabulum, median or slightly lateral; ovary lateral, close behind ventral acetabulum; testes large, close together, halfway between ventral acetabulum and posterior end; vitellaria lateral.

Sub. fam. Allocreadiinae. Uterus short with few coils between anterior testis and ventral acetabulum.

No papillae around anterior end. Allocreadium.

Six papillae around anterior end; genital pore anterior to intestinal fork. Crepidostomum.

Genital pore posterior to intestinal fork. Acrolichanus.

Sub. fam. Bunoderinae. Uterus ventral to both testes; extending nearly to posterior end.

Testes oblique, far back in body, Bunodera.

Testes small, central Auridistomum.

Testes numerous, in two longitudinal series. Pleorchis.

Distomid infection is not as a rule pathogenic to the fish unless very intense. Infection arsises from ingestion of insect larvae containing distomid larvae.

References: Plehn (1924); Ward and Whipple (1928).

Nannophyosis

An infection of the gills, muscles and kidneys of Salmo and Oncorhynchus in western North America with encysted larvae of Nannophyes salmincola (Chapin 1926).

So far as is known the presence of this organism is not pathogenic to the salmon but the mature fluke provokes in dogs which have fed upon infected fish a severe haemorrhagic inflammation of the intestine, often terminating fatally.

References: Cram (1926).

Pop-eye Disease

An infection of the tissues of trout fry with encysted immature distomid flukes; recorded only in Oregon by Ward and Mueller (1926).

Causative organism: prpvisionally termed Distomulum oregonensis; primary host unknown. Cyst spherical, 166 - 246μ in diameter, transparent, resistant, 7 - 8μ thick; encysted fluke slightly compressed, ellipsoidal, 146μ by 160μ to 210μ by 190μ; oral acetabulum 70μ in diameter, ventral acetabulum 65μ in diameter; intestinal branches widely divergent; excretory bladder large, testes oval, conspicuous; ovary represented by U-shaped curve of nuclei posterior to ventral acetabulum.

Symptoms: erratic movements ending in death; eyeballs often protrude conspicuously; tissue showing immense numbers of minute cysts, abundant at base of fins, in tissue of orbit, around eye capsule, in eyeball muscles.

References: Ward and Mueller (1926).

Enteric cestodosis

An infection of the alimentary tract with adult or larval tapeworms.

Causative organism: the following genera of adult tapeworms--Cyathocephalus, Diplocotyle, Eubothrium, Proteocephalus -- and the following genera of larval tapeworms -- Nybelinia, Phyllobothrium -- have been recorded from the alimentary tract of salmonoid species of fishes. These genera possess the following diagnostic features:-

Cyathocephalus: small tapeworms, not exceeding two inches in length, provided with a funnel-like scolex, showing very slight external segmentation of the strobila and having two genital apertures in the middle of one or other surface of each segment; the anterior aperture is the male aperture, the posterior aperture represents the aperture of a cloaca into which vagina and uterus open; uterus a coiled canal.

Cyathocephalus truncatus is recorded in Europe from Coregonus, Salmo, Thymallus and Salvelinus, and in Canada from Coregonus, Salmo and Salvelinus.

Diplocotyle: small tapeworms provided with a spherical scolex which has two terminal openings; external segmentation completely absent; genital apertures as in Cyathocephalus but a well developed sphincter muscle present around the Cloacal aperture.

D. olrikii occurs in Europe and northern Canada in Salvelinus alpinus and Salvelinus stagnalis.

Eubothrium: Large tapeworms up to 24 inches long by one fifth of an inch broad provided with a scolex which has a terminal cap and two lateral round or oval bothrial depressions; strobila clearly segmented; common genital aperture marginal; uterine pore median and on the surface of the segment.

The species -- crassum, salvelini -- have been recorded from European and Canadian salmonids; E. oncorhynchi is recorded in the Pacific salmon.

Proteocephalus: medium sized tapeworms provided with a small rounded scolex capable of considerable mobility and having four circular adhesive cups and sometimes a fifth terminal cup; genital pores marginal irregular, alternating; external segmentation distinct; no uterine pore; vitellaria numerous, in two lateral zones.

The species: fallax, longicollis, neglectus, are recorded in Europe from

Coregonus sp. In North America, the species exiguus, laruei, arcticus, are recorded from Coregonus; pusillus from Salmo sebago and Christivomer namaycush.

Nybelina: typical tetrarhynchid larva occurring in the stomach of Pacific salmon; up to one third of an inch in length; provided with four oval shallow brothria and four cylindrical proboscides armed with spiral rows of small equal hooks; there is a tail-like appendage withdrawn within the body of the larva.

Phyllobothrium: typical phyllobothriid larvae up to half an inch in length, common in the intestine of Pacific salmon; the larva may be completely enclosed within a pyriform or club-shaped cyst or may be free in the gut, showing when free four ear-like stalked bothria each provided with a pit-like, deeper accessory sucking cup; a small apical sucking cup is also present; body unsegmented but wrinkled. The larva has been recorded by Fujita (1922) as Phyllobothrium salmonis from Japanese salmonoids, and in the adult stage, by Canavan (1928) as Phyllobothrium ketae from the Alaska Dog Salmon.

References: Fujita (1922); Ward (1918); Cooper (1917); Nybelin (1922), Canavan (1928); Wardle (1932a, 1932b); De la Rue (1914).

Somatic Cestodosis

An infection of the body tissues, outside the alimentary tract, by larval tapeworms.

Causative organism: the commonest larval cestodes infecting salmonoid fishes belong to the genera Triaenophorus, Diphyllobothrium, and Ligula.

Triaenophorus: the larva occurs intermuscularly, coiled within a whitish bladder-like cyst in the midst of a yellow pus-like fluid. The adult host is

some species of Esox. The larva measures up to ten inches in length, is slender, white, and provided with a scolex which has two bothrial depressions and a rectangular terminal cap at each of whose corners is a three-toothed horny structure.

T. tricuspidatus and T. robustus have been recorded in Europe and in North America as larval forms in Coregonus and Leucichthys.

Diphyllobothrium: the larval stages of this genus are typical flattened, oval, tapering worms, up to a quarter of an inch in length, provided at one end with two slit-like bothrial depressions; the body is wrinkled but unsegmented; they occur typically folded in a U-shape within a bladder-like cyst, such cysts usually being very numerous in an infected fish and attached to the peritoneal lining of the body cavity or to the peritoneal surface of the alimentary tract; some larvae occur wandering free between the muscles.

A number of diphyllobothriid larvae have been recorded from salmonoid fishes but have not been identified with certainty with adult species of Diphyllobothrium, although undoubtedly stages of such species in birds and mammals.

Ligula: small, flattened larvae with a bluntly rounded anterior end provided with a terminal cleft, representing the adhesive depressions of other genera; segmentation absent or present only at the anterior end; adults in water birds. Ligulid larvae occur usually in the body cavity but may be found in young salmonoids embedded partially in the liver.

References: Cooper (1917); Ward (1918); Plehn (1924); Linton ( ); Fasten (1922); Wardle (1932a, 1932b, 1932c); Newton (1932).

Enteric Ascarosis

Infection of the alimentary tract with nematode worms belonging to the superfamily Ascaroidea.

Comparatively few nematode species have been recorded from the alimentary tract of salmonoid fishes but in Europe the following species are recorded:- Ascaris obtusocaudata, Ascaris acus, Ascaris dentata.

Somatic Ascarosis

Infection of the connective tissue, liver, muscles, etc. with encysted coiled, immature ascarids.

The general designation of Agamonema capsularia is given to these forms but probably a number of different forms are covered by this term. The Agamonema of Salmo salar may be larval stage of some species of Porrocaecum, of some fish eating mammal or bird.

There occurs occasionally among hatchery trout in Europe an epidemic disease characterized by severe inflammation of the alimentary tract and occasioned by an intense infection of the liver and pyloric caeca with immature ascarids about one millimetre in length. They occur encysted in masses in the liver tissue and in the gut muscles and provoke extensive destruction of the tissues. The primary host is unknown. A similar condition occasionally occurs in Coregonus clupeaformis in Western Canada.

Cystidicolosis

Infection of the swim bladder with a spiruroid worm.

Causative organism: Cystidicola. C. farionis and C. impar in Europe;

Cl. stigmatura in N. America.

ARTHROPODOSES

Salmonoid fishes are liable to infection by skin parasites or gill parasites belonging to certain families of the crustacean order Copepoda; the families concerned are the Argulidae, Caligidae, Lernaeopodidae.

Argulidae.

Ectoparasitic upon the skin of fishes but not occurring on the gills, and commonly termed fish lice. They are disk-shaped, flattened, and attached to the host by a pair of sucker-like organs representing modified maxillipedes; they are actively mobile, readily migrating from fish to fish; the food is blood, obtained through a piercing proboscis. The Argulids of anadromous fishes appear well able to tolerate changes from fresh water into salt water and vice versa.

Argulis foliaceus: is common Salmo trutta all over Europe, Argulis coregoni, Thorell, occurs on Coregonus lavaretus, Thymallus vulgaris and Salmo trutta also in Europe.

Argulis pugettensis, Dana, is recorded from Oncorhynchus kisutch in Pacific American waters.

Caligidae.

Somewhat flattened organism with the caudal region of the abdomen much reduced as compared with free-living copepoda; they adhere to the host by antennae which are hooked at the end. The females carry their eggs with them and their freedom of movement is thus considerably restricted.

Their food is the blood of the host.

Caligid parasites appear somewhat susceptible to heat, an increase in the

environmental temperature of only a few degrees above normal being quickly fatal but they can withstand severe cold, even freezing temperatures, without apparent injury.

They show a decided preference for Pleuronectid and Gadid hosts but may be found temporarily upon almost any fish host.

Lepeophtheirus salmonis, Kroyer, is common on salmonoids of the American coasts and European coasts, particularly Salmo salar, Salvelinus malma and Oncorhynchus gorbuscha and can remain with the host on its passage into fresh water.

L. pacificus, Gissler, has been recorded from Oncorhynchus nerka in Puget Sound.

Lernaeopodidae.

Bloodsucking ectoparasites attached permanently to the gills or fins of the host fish by the second maxillipedes which are large, and arch over the head to unite into an organ of attachment; the head is distinct, often borne on a long neck; the rest of the body is sac-like and unsegmented; no swimming limbs are present; the egg sacs are large and jointed, the parasites are all females, the males being pygmy-like, clinging to the body of the female, but free to move about.

The species recorded from salmonoid fishes belong to the genera Salmincola, Achtheres and Lernaeopoda and are comparatively numerous. Reference may be made to Wilson (1915) for the diagnostic characters of these species.

Remedies against fish lice.

Infection of fishes by fish lice is usually effected by free-swimming larval stages; an individual fish may be heavily attacked and suffer severely

from the loss of blood taken by the parasites. The gill filaments in particular may be reduced in function by the scar tissue developed as a response to parasite injury. In a crowded hatchery fish may die in large numbers from the attack of fish lice.

Fasten (1918) suggests the following prophylactic measures:

(1) Provision of sand filters at the mouth of the water intake.

(2) Frequent salt baths for young fry.

(3) Provision of powerful arc lights at various points over the fish ponds; the free-swimming larval stages are attracted to the surface water in the region of these lights and can be removed by fine gauze bags towed over the illuminated regions.

(4) The introduction of minnows, dace and roach into hatchery ponds, these fishes feeding voraciously on free-swimming copepod larvae.

No way of freeing a fish from the parasites is known as the parasites are more resistant to chemical baths than are the host fishes.

References: Fasten (1918); Ward and Whipple (1918); Wilson (1915), (1908); Wright (1882).

NON-PARASITIC DISEASES

This category may be created to include a miscellaneous group of diseases which only agree in being non-parasitic in origin but due to some functional disturbance of the organ of the body affected.

Thyroid Disease

A disease recorded in North America, Europe and New Zealand frequently in epidemic form, characterized by the enlargement of the thyroid gland, show-

ing as a tumour extending into the pharynx and showing externally as a conspicuous pink swelling projecting on both sides of the gill clefts.

Symptoms: the first indication of thyroid proliferation is the "red" floor", a reddening of the floor of the mouth opposite the second gill arches; when the fish is removed from the water the pink colour fades to a dark grey; this stage is followed by one in which appear pink protusions on the ventral surface of the head at the junction of the first pair of gills; these protrusions grow in size, push the gill covers apart, protde into the gill spaces. Simultaneously the proliferating thyroid tissue infiltrates into the floor of the mouth and a bulging mass pushes into the floor of the mouth.

Usually only the larger tumours are noticed since the determination of thyroid tumour in its early stages necessitates an examination of the mouth and branchial chambers. The disease may pass unnoticed, may pursue a slow chronic course until the increasing growth of the tumour interferes with respiration and feeding and brings about death.

Pathological histology: The normal thyroid of the salmonoid fish is not a defined glandular unit enclosed by a capsule but consists of a collection of alveoli diffused in connective tissue between the ventral aorta and the floor of the branchial basket in the region of the first and second gill arches. Each alveolus is closed and independent of the others, is spherical or subspherical, 0.02 - 0.75 mm. in diameter and consist of a single layer of flattened polyhedral epithelial cells each containing a homogeneous substance termed "colloid".

In one common pathological condition of the thyroid the alveoli are closely packed, show great irregularity in shape, show pouch like branching of the typical round or oval alveoli; the ~~pe~~ epithelium is cuboidal or columnar, the colloid diminished in amount or absent. This condition is known as <u>hyper-</u>

plasia. Or the alveoli may be greatly enlarged, their walls very thin, the epithelium pressed very flat, and the cavities compactly filled with compact masses of colloid; this condition may be referred to as colloid goitre. Or again, instead of the condition of hyperplasia terminating in colloid goitre, the alveoli may bud off irregular groups of cells or tubules or groups of irregularly shaped alveoli lined with columnar epithelium. The new growth penetrates into the surrounding tissue, even into muscles, bones and cartilage, as a malignant infiltrating type of tumour which resembles in some phases of its histology the mammalian carcinoma, or in others, mammalian sarcoma or in some phases even resembles malignant papilloma. Secondary growth or metastases may appear on the tip of the lower jaw or even in the alimentary tract.

Control: The disease is primarily a disease of hatcheries, and associated with a diet of uncooked animal protein and with a deficiency of iodine. Pacific salmon hybrids are particularly susceptible. On the other hand some salmonoids such as the Scotch salmon are immune. Some fish show spontaneous recovery. A diet of marine fishmeal, vegetable food, insect food, appears to oppose the development of the disease. Addition of iodine or mercury to the water--in the form of potassium iodide and mercuric chloride--1:200,000 in the case of iodine, 1:5,000,000 of mercury -- appears to check the progress of the disease. Davis (1929) recommends the addition of a tablespoonful of Lugols solution (1% iodine in 1% potassium iodide) to each 50 lbs. of ground food.

References: Gaylord and Marsh (1912); Davis (1929).

Whitespot Disease

A disease of salmonoid eggs and fry characterized by an opaque or white area in the yolk, due to localized coagulation of the yolk. The primary cause is unknown. Bacteria occur in the whitespot area but no one type appears to predominate and there is no evidence that the disease is contagious. There is usually in the whitespot area an undue aggregation of periblast cells, the yolk absorbing cells.

The probable primary cause may be any injury to the yolk sac which permits the entrance of saprophytic bacteria or even mechanical injury, such as shock or concussion or extreme cold, which may stimulate the attack of periblast cells.

References: Leach (1923); Davis (1929).

Blue Sac Disease

A disease commonly called Yolk sac Dropsy or Hydrocoele Embryonalis, of salmonoid fry before the yolk sac is absorbed, and characterized by a dropsical condition of the yolk sac which eventually bursts, the fry then dying.

The swelling of the yolk sac is due to the appearance of a bluish coloured serous fluid between the yolk and yolk sac. A diplobacillus has been found to occur in this fluid and by some authorities has been regarded as the causative organism.

Injury or shock appear to be predisposing factors.

References: Von Betegh (1912); Leach (1923); Davis (1929).