apparent nonculturable or dormant state[2]. Although the inability to culture the pathogen from outwith fish may to some extent reflect an incomplete knowledge of subtle nutritional requirements, it should be emphasised that such a phenomenon could explain the explosive outbreaks of furunculosis in farmed salmonids, which have not experienced previous contact with diseased fish[11]. Moreover from laboratory-based experiments, it has been demonstrated that salmonids may indeed succumb to furunculosis following exposure to aqueous suspensions of the pathogen[4,8,11]. In a series of experiments using virulent and non-virulent cultures of *A. salmonicida,* which were grown in nutrient-rich (3.7% w/v BHIB) and nutrient-limited conditions (0.1% w/v BHIB), it was demonstrated that uptake of the pathogen into fish, i.e. rainbow trout, occurred within 2 min[8]. Thus, colonies of *A. salmonicida* developed on a selective isolation medium, peptone beef extract glycogen agar[10], following inoculation of tissue homogenates and blood with incubation at 22 °C for 48 h. Generally, the data revealed that low numbers, i.e. 2–25 cells of *A. salmonicida,* could be detected in the blood, kidney and spleen of the rainbow trout within 2-min exposure to the pathogen. There was negligible difference in the uptake of virulent or nonvirulent isolates. However, there was better uptake of cells derived from 0.1% (w/v) BHIB and in the presence of particulates, namely latex particles, compared to the other combinations. Superior uptake occurred by immersing the entire fish rather than just the head or tail regions. In all cases, the bacterial cells could not be detected in the fish after 24 h, and for that matter, furunculosis did not develop[8].

By examination of parallel samples by FAT, the presence of large numbers of bacteria in close contact with gill epithelial cells were observed within the 2-min exposure period. However, this is not surprising in view of the anticipated close contact between gills and bacterial suspension. Nevertheless, there was no evidence to indicate uptake of *A. salmonicida* across the gill epithelia, insofar as the bacteria were not observed in epithelial cells or within the capillaries. *A. salmonicida* was also observed as isolated cells on the lining of the lower intestine and rectum within 1 h after exposure to the bacterial suspension. Interestingly, such bacterial cells were not observed 3 h later, either indicating uptake into or elimination from the fish. There was no firm evidence for transport of *A. salmonicida* across the gut wall. Yet, this possibility was worthy of further investigation.

Certainly studies, to date, point to the presence of *A. salmonicida* on particulates in the aquatic environment, outwith of salmonids. It must be assumed that these cells comprise potential foci for infection of fish when certain, as yet unknown, conditions prevail. Such factors are likely to include the physiological state of the bacterial cells, which will be influenced by water temperature and the availability of specific nutrients, as well as the presence of appropriately 'stressed' fish. Then, uptake of the bacteria into fish occurs with considerable speed, indicating active rather than passive processes.

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Extraintestinal *Aeromonas* and *Plesiomonas* infections of humans

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Key words. Aeromonas; Plesiomonas; sepsis; meningitis; cutaneous infections; ecthyma gangrenosum; myositis; osteomyelitis; suppurative arthritis; pneumonia; peritonitis; cholecystitis; ocular infections.

Like other human enteric pathogens, *Aeromonas* and *Plesiomonas* can cause infections at sites outside the gastrointestinal tract[3,6]. Although these infections are uncommon, they tend to be severe and often fatal, particularly in individuals with impaired immunity. Based on published case reports, extraintestinal *Aeromonas* disease appears to be more frequent and varied than that due to *Plesiomonas* (table). Infections occur worldwide and patients of all ages have been described.

Sepsis. About 200 instances of *Aeromonas* bacteremia or sepsis have been recorded in the literature but clinical data are not available for all cases. Children and adolescents account for at least one-fourth of all patients. The majority have chronic underlying disorders including leukemia, solid tumors, aplastic anemia, hemoglobinopathies, cirrhosis, or renal failure. Patients with malignancies who develop *Aeromonas* sepsis are typically in relapse or have never achieved remission. The mortality rate exceeds 50% in spite of early treatment with antibiotics to which *Aeromonas* is susceptible in vitro[4,7]. Sepsis is frequently accompanied by infections of other sites such as the skin or lungs. When properly speciated, most blood isolates are found to be either *A. hydrophila* or *A. sobria*[9]. The source of *Aeromonas* is assumed to be the gastrointestinal tract although this organism has only infrequently been isolated from bacteremic patients from whom stool cultures were obtained.

Nine patients with *Plesiomonas shigelloides* sepsis have been described[3,8,10]. Five were neonates and the rest had underlying disorders such as sickle cell anemia, liver disease, cardiomyopathy, or rheumatoid arthritis. Eight had other foci of infection such as cellulitis, pneumonia, arthritis, or meningitis and the ninth was a neonate with mixed *Aeromonas* and *Plesiomonas* sepsis. Seven (78%) patients died.

Meningitis. Seven cases of *Aeromonas* meningitis have been reported to date[1,5,6]. They ranged in age from 13 days to 37 years. Underlying conditions included hemoglobinopathies, leukemia,

and splenectomy. One adult developed *Aeromonas* postcraniotomy meningitis. Seizures occurred in the four patients who were two years of age or younger. The organism was isolated from five of seven cerebrospinal fluid cultures and all blood cultures. Three patients died.

Four neonates with *Plesiomonas* meningits have been described[3]. All were apparently healthy at birth but became ill within the first four days of life. Three developed seizures and all four died by the fifth day of life.

Cutaneous infections. Both immunocompetent and immunocompromised hosts can develop *Aeromonas* wound infections. Exposure of wounds to presumably contaminated water has been noted in about half the cases. The infection progresses rapidly over a few hours in many individuals and may be accompanied by fever and leukocytosis. Gas formation suggestive of clostridial disease has been noted in some *Aeromonas*-infected wounds. Ecthyma gangrenosum, previously believed to be pathognomonic of *Pseudomonas* sepsis, occurs in about 10% of patients with malignancies complicated by *Aeromonas* sepsis[7]. Bacteremia may also follow a primary *Aeromonas* or *Plesiomonas* wound infection[3,6]. Patients with cutaneous *Aeromonas* infections have been treated with antibiotics, surgical debridement, or both. The response to therapy was usually good but three patients with severe disease required amputation of infected limbs[6].

Musculoskeletal infections. Necrotizing *Aeromonas* myositis may result from a penetrating injury or from hematogenous spread of the organism and has been described in 14 patients[6]. Therapy consisted of antibiotics with or without surgical debridement. Amputation of the affected limb was required in four patients. Eight (57%) patients died.

Suppurative arthritis has been described in three patients with leukemia and *Aeromonas* sepsis[6], none of whom was in remission, and in one elderly patient with rheumatoid arthritis and *Plesiomonas* sepsis[3]. Three patients had knee arthritis and the fourth developed infection of a metacarpophalangeal joint during the course of *Aeromonas* sepsis with multisystem involvement. The organisms could be isolated from blood and synovial fluid cultures in all cases. All four patients died. *Aeromonas* osteomyelitis may follow trauma or bacteremia and has been documented in eight patients[6]. Lower extremity bones are the ones typically involved.

Miscellaneous infections. Pulmonary disease may occur during the course of *Aeromonas* sepsis or as aspiration pneumonia in patients with near-drowning. *Aeromonas* peritonitis may complicate intestinal perforation or peritoneal dialysis but can also arise as a spontaneous bacterial infection in patients with hepatic cirrhosis. Several cases of acute cholecystitis with or without ascending cholangitis due to *Aeromonas* have been reported[6] but only two caused by *Plesiomonas*[2,11]. Ocular *Aeromonas* infections manifesting as corneal ulcers or conjunctivitis are usually caused by penetrating eye injuries. One child developed endophthalmitis following a fish hook injury to the eye and cultures from the anterior chamber of the enucleated eye grew both *A. hydrophila* and *P. shigelloides*[6]. Urinary isolates of *Aeromonas*, more commonly found in association with other organisms, have usually been recovered from patients with chronic genitourinary tract disorders such as hydronephrosis.

Extraintestinal human infections caused by *Aeromonas* and *Plesiomonas*

Pathogen	Type of infection
Aeromonas	Sepsis, meningitis, cellulitis, necrotizing fasciitis, ecthyma gangrenosum, pneumonia, peritonitis, conjunctivitis, corneal ulcer, endophthalmitis, osteomyelitis, suppurative arthritis, myositis, subphrenic abscess, liver abscess, cholecystitis and/or ascending cholangitis, urinary tract infection, endocarditis, ear, nose, and throat infections, septic abortion, balanitis, vaginal discharge
Plesiomonas	Sepsis, meningitis, cellulitis, suppurative arthritis, cholecystitis, endophthalmitis, pyometra

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Antimicrobial susceptibilities of *Aeromonas* species and *Plesiomonas shigelloides*

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Key words. Aeromonas hydrophila; Aeromonas species; *Plesiomonas shigelloides;* antimicrobial susceptibilities.

Prior to 1980, antimicrobial susceptibilities of *Aeromonas* species and *Plesiomonas shigelloides* were determined primarily by disk diffusion testing. These organisms were typically susceptible to chloramphenicol, trimethoprim-sulfamethoxazole (TMP-SMZ), tetracycline, aminoglycosides and nalidixic acid, variably susceptible to erythromycin and polymyxins, and resistant to penicillin G, ampicillin, carbenicillin and cephalothin[7].

During the past six years, we have been testing the in vitro activities of antimicrobial agents against *Aeromonas hydrophila* with a standardized microdilution method using cation-supplemented Mueller-Hinton broth and an inoculum of 5×10^5 cfu/ml[11]. The minimal inhibitory concentrations (MICs) for 42 antimicrobial agents[3–6] are shown in table 1. Although aeromonads isolated from aquatic environments have shown significant fre-