

In Vitro Susceptibilities of Tropical Strains of *Aeromonas* Species from Queensland, Australia, to 22 Antimicrobial Agents

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Greater than 90% of 131 strains of *Aeromonas* species were susceptible to the aminoglycosides, ureidopenicillins, extended-spectrum cephalosporins, aztreonam, quinolones, tetracycline, and chloramphenicol, and all were uniformly resistant to ampicillin. Except for amoxicillin-clavulanate, sulfonamide, trimethoprim, and trimethoprim-sulfamethoxazole, there was good correlation between the results obtained by the agar dilution and disk diffusion techniques.

Until recently, antimicrobial susceptibility studies of motile aeromonads have been undertaken with isolates simply specified as *Aeromonas hydrophila* (4, 5, 14). Because various infective processes and virulence factors correlate with different *Aeromonas* species, later studies have investigated the antimicrobial susceptibility of each of the three *Aeromonas* species to assist clinical management (2, 10). These studies have demonstrated that the activities of various antimicrobial agents against these bacteria show some species-associated trends. Within certain antibiotic groups, such as the cephalosporins (8), there is variability in activity among drugs when they are tested against individual isolates. Since most antibiotic susceptibility studies have been performed on the *A. hydrophila* complex, it is difficult to determine whether these variabilities are due to the difference in aeromonads at the species level (16), the geographic origin of the isolates (11), the methods of susceptibility testing (14), or other factors. Geographic differences in the distribution of *Aeromonas* species are evident. *A. sobria* infection is common in Australia (30% of strains isolated from stools) but rare in other countries (11). The relative frequencies of distribution of the three species of aeromonads in humans throughout countries other than Australia appear to be similar, with more than half of the isolates being *A. caviae* (8, 11). Knowledge of susceptibility patterns of local aeromonad strains is important, so that medical practitioners know the likelihood of activity of various antibiotics for empirical therapy of suspected aeromonad infection. However, little is known of the antibiotic patterns of *Aeromonas* species in Australia, in particular, in the tropics of Queensland. The following study was undertaken to determine the in vitro activities of 22 antibiotic agents commonly used against northern Queensland strains of *Aeromonas* species.

Collected from 1 January 1991 to 30 June 1992 from the tropics of Queensland, 131 strains of *Aeromonas* species of human origin were tested. Seventy-four isolates were *A. hydrophila* (51 from wounds, 20 from feces, 1 from a blood culture, 1 from urine, and 1 from a gastric aspirate), 31 were *A. sobria* (18 from wounds, 12 from feces, and 1 from a blood culture), 25 were *A. caviae* (5 from wounds and 20 from

feces), and 1 was *A. schubertii* (from a blood culture). The isolates were identified to the species level by the criteria described by von Graevenitz (17), and production of β -lactamase was detected by the chromogenic cephalosporin (nitrocefin) test. The breakpoint for each strain against each antibiotic agent was determined by using the National Committee for Clinical Laboratory Standards procedures for the agar dilution method (13). The breakpoint was recorded as the lowest concentration of an antimicrobial agent that completely inhibited growth, disregarding a single colony or a faint haze caused by the inoculum. *Aeromonas* isolates were also tested for susceptibility by following the procedures outlined by the National Committee for Clinical Laboratory Standards for the disk diffusion method (12). Because interpretative criteria have not been established for *Aeromonas* species, National Committee for Clinical Laboratory Standards criteria and tentative standards recommended by the manufacturers for the fluoroquinolones for members of the family *Enterobacteriaceae* were used for breakpoints for susceptible, moderately susceptible, and resistant categories for both the agar dilution and disk diffusion methods (12, 13).

All 131 isolates of *Aeromonas* species from northern Queensland were found to be β -lactamase-producing strains. The results of in vitro susceptibility tests of strains of *A. hydrophila*, *A. sobria*, and *A. caviae* by the agar dilution and disk diffusion methods against 22 antibiotics are given in Table 1. With the agar dilution technique as the standard, all strains were uniformly susceptible to azlocillin, neomycin, gentamicin, amikacin, netilmicin, cefotaxime, ceftazidime, ciprofloxacin, norfloxacin, and chloramphenicol and uniformly resistant to ampicillin. All strains of *A. sobria* and *A. caviae* were also uniformly resistant to amoxicillin-clavulanate and cephalothin, respectively. Greater than 95% of all strains were susceptible to ceftriaxone, aztreonam, piperacillin, and tetracycline, while >95% of *A. sobria* strains were susceptible to cephalothin. Except for amoxicillin-clavulanate, cephalothin, and cefoxitin for both *A. hydrophila* and *A. caviae*, greater than 75% of all strains were susceptible to the remaining antibiotics. All strains of *A. caviae* and 90% of strains of *A. hydrophila* were resistant to cephalothin. There was good correlation between the results obtained by the agar dilution and disk diffusion techniques, except for amoxicillin-clavulanate for both *A. hydrophila*

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TABLE 1. In vitro susceptibilities of 74 strains of *A. hydrophila*, 31 strains of *A. sobria*, and 25 strains of *A. caviae*, isolated in northern Queensland by the agar dilution and disk diffusion methods, against 22 antibiotics

Antibiotic	% of <i>A. hydrophila</i> strains						% of <i>A. sobria</i> strains						% of <i>A. caviae</i> strains					
	Agar dilution			Disk diffusion			Agar dilution			Disk diffusion			Agar dilution			Disk diffusion		
	S ^a	I ^b	R ^c	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R
Penicillins																		
Ampicillin	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100
Amoxicillin-clavulanate	41	47	12	3	0	97	0	0	100	0	0	100	32	60	8	6	0	94
Azlocillin	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	96	0	4
Piperacillin	100	0	0	100	0	0	97	3	0	100	0	0	96	4	0	94	0	4
Aminoglycosides																		
Neomycin	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
Gentamicin	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
Tobramycin	92	0	8	92	0	8	90	0	10	90	0	10	91	0	9	91	0	9
Amikacin	100	0	0	97	0	3	100	0	0	100	0	0	100	0	0	97	0	3
Netilmicin	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
Cephalosporins																		
Cephalothin	10	0	90	9	0	91	98	0	2	98	0	2	0	0	100	0	0	100
Cefoxitin	61	4	35	66	4	30	100	0	0	95	5	0	52	20	28	55	20	25
Cefotaxime	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
Ceftriaxone	99	1	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
Ceftazidime	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
Quinolones																		
Ciprofloxacin	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
Norfloxacin	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
Others																		
Tetracycline	100	0	0	100	0	0	97	3	0	100	0	0	100	0	0	100	0	0
Sulfonamide	76	5	19	97	0	3	87	0	13	100	0	0	72	8	20	92	0	8
Trimethoprim	80	5	15	94	0	6	90	9	1	100	0	0	80	10	10	92	0	8
Trimethoprim-sulfamethoxazole	81	3	16	100	0	0	90	4	6	100	0	0	80	8	12	92	0	8
Chloramphenicol	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
Aztreonam	99	0	1	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0

^a S, susceptible.^b I, moderately susceptible.^c R, resistant.

and *A. caviae* and sulfonamide, trimethoprim, and trimethoprim-sulfamethoxazole for all three species. The single strain of *A. schubertii* was resistant to trimethoprim and ampicillin, moderately susceptible to tobramycin, and susceptible to all of the other 19 antimicrobial agents tested.

The present study has shown that strains from the tropics of Queensland are similar in their susceptibility patterns to *Aeromonas* strains from the temperate climes of Europe and the United States for the aminoglycosides, the broad-spectrum cephalosporins, the quinolones, the ureidopenicillins, tetracycline, chloramphenicol, aztreonam, cephalothin, and ampicillin (2, 4, 5, 10, 14, 18). The antibiogram of the single northern Queensland strain of *A. schubertii* was the same as that obtained from strains isolated in the United States (7). Although the number of strains tested previously from Western Australia and New South Wales was small, there appeared to be no significant difference in the susceptibility of *Aeromonas* species between northern Queensland strains and strains from these other regions of Australia for the commonly used antibiotics ampicillin, chloramphenicol, tetracycline, and gentamicin. Other antibiotics were not tested in earlier Australian studies (3, 6, 15).

Major discrepancies exist between the disk diffusion and agar dilution susceptibility results obtained for amoxicillin-

clavulanic acid with *A. hydrophila* and *A. caviae* and those obtained for sulfonamide, trimethoprim, and trimethoprim-sulfamethoxazole with all three species. The false-resistant amoxicillin-clavulanic acid disk test results and the false-susceptible trimethoprim and trimethoprim-sulfamethoxazole disk test results seen with these four antibiotics exceeded the proposed acceptable rate of 5% (9). Inherent problems exist with disk diffusion susceptibility testing for sulfonamide, trimethoprim, and trimethoprim-sulfamethoxazole, and agar or broth dilution techniques are the standard method for testing susceptibility to these drugs (12, 13). The reasons for the aberrant results between the agar dilution and disk diffusion methods for amoxicillin-clavulanic acid are unclear.

Of the three species tested, *A. sobria* was considerably more susceptible (98%) to cephalothin than was either *A. hydrophila* (10%) or *A. caviae* (0%), a useful tool to assist in species identification (8). All strains of the three species were also resistant to ampicillin. It was previously thought that resistance to ampicillin might be due solely to production of β -lactamases by the aeromonads (1). The inclusion of the β -lactamase inhibitor clavulanic acid did increase the number of strains of *A. hydrophila* (41%) and *A. caviae* (32%) that were susceptible to the ampicillin analog amoxi-

cillin, but all strains of *A. sobria* remained resistant. It is therefore obvious that resistance of *Aeromonas* spp. to ampicillin for most strains is due to more than β -lactamase production. In gram-negative rods, decreased permeability for antibacterial agents, as well as decreased affinity of these drugs for specific binding proteins in the cytoplasmic membrane, also appear to influence susceptibility (18). Ratios of resistance of each of the three species to amoxicillin-clavulanic acid found in this study were similar to those reported with European *Aeromonas* strains (2).

Differences in susceptibility in all three *Aeromonas* species were detected between gentamicin and tobramycin, two aminoglycoside antibiotics which have similar modes of activity. A difference in susceptibility between gentamicin and tobramycin was also noted in 23% of *Aeromonas* species isolated from blood cultures in New South Wales (3). This is of clinical significance because tobramycin is commonly used in preference to gentamicin in the empirical treatment of immunocompromised septic patients. This is because tobramycin is slightly more active than gentamicin against *Pseudomonas aeruginosa*, a pathogen common in this group of patients. However, it is this group of patients in which *Aeromonas* species (predominantly *A. sobria*) also occurs in the septicemic form (3, 8). Physicians in regions where community-acquired or nosocomial aeromonad infections occur frequently, as in the tropics of Queensland, should be alerted to this incongruity.

Identification of *Aeromonas* isolates to the species level has important implications for the selection of antimicrobial therapy for infections involving these organisms. On the basis of the in vitro results obtained with the antibacterial agents tested, gentamicin, aztreonam, extended-spectrum cephalosporins, ureidopenicillins, chloramphenicol, tetracycline, or a quinolone should be considered for therapy of aeromonad infections caused by northern Queensland strains. The low MICs and high concentrations attainable in feces and in tissue indicate that quinolones may be efficacious as orally administered drugs for the treatment of *Aeromonas*-associated diarrhea and *Aeromonas* soft-tissue infections.

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