BACTERIAL AND FUNGAL DISEASES OF PET BIRDS

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1. **Bacterial Diseases**

   A. Most common problem diagnosed in avian species
      i. If you work with birds, you may develop a strong desire to reach for antibiotics and antifungals in every case
         a. Why? By the time a veterinarian sees a sick bird, it is compromised and such birds routinely have bacteria or fungi waiting to invade their system.
      ii. As progressive veterinarians, you should at least make an attempt to justify the use of your drugs

2. **What do you need to know to diagnose and treat? (Besides some drug dose)**

   A. Normal flora by avian species and system location
   B. Abnormal flora
   C. Host range
   D. Clinical signs
   E. Therapy and control

3. **Normal Flora of Pet Birds**

   A. Species of pet birds
      i. Psittacine birds
      ii. Finches and canaries
      iii. Columbiform birds; pigeons, doves
   B. Normal flora by system
      i. Normal gut flora determined by diet
         a. Granivorous and fructivorous birds do not normally have Gram-negative bacteria in gut flora (Whitford,1978)
         b. Insectivorous and carnivorous will have a predominance of Gram-negative coliforms (Whitford, 1978)
      ii. Normal cloacal and choanal flora are primarily Gram positive in pet birds (Jones,1980, Bowman,1980, Glunder,1981, Flammer, 1988, Lane,1991)

a. Faeces, cloaca, choana; genera *Lactobacillus, Staphylococcus, Streptococcus, Bacillus, Corynebacterium.*
b. *Alysiella filiformis* is a normal Gram-positive organism of the upper alimentary tract; unicellular bacteria arranged in unbranched, ribbon-like filaments
c. *Escherichia coli* was the most frequent Gram-negative isolate, ranging from 5% to 42% depending on the study.
* Other Gram negative organisms identified were: *Pseudomonas sp., Enterobacter cloacae, E. aerogenes, Alcaligenes faecalis, Klebsiella pneumoniae, K. oxytoca, Flavobacterium odoratum, Erwineae carotovora, Proteus vulgaris, Acinetobacter calcoaceticus*, and *Citrobacter freundii.*
d. Granivorous passerine birds such as finches and canaries
* Usually rare bacteria found on Gram stains
* No growth on aerobic cultures

iii. Skin
a. Small numbers of *Staphylococcus* sp. and *Streptococcus* sp.

iv. Mostly sterile
a. Trachea and air sacs
* Rare *Staphylococcus* sp. or *Streptococcus* sp.
b. Ocular conjunctiva
* *Genera Staphylococcus, Streptococcus, Corynebacterium*.
* In one study, no microbial growth in 41% of the samples (Zenoble 1983)
c. Internal organs
* Genera *Bacillus, Corynebacterium, Streptococcus, Staphylococcus*.
* Liver and kidney
** Because of hepatic and renal portal system, no lymph nodes to filter

C. Sterile
i. Eggs, newly hatched chicks
a. Once hatched, nestlings are inoculated by microorganisms from the environment via food provided by parents, ingestion of adult saliva and from nest materials (Hager, 1988)

ii. Joints

D. Anaerobic bacteria
i. Rare isolates, although few studies have cultured for their presence.
a. One unclassified anaerobic Gram negative organism was identified from a study of the cloacal flora of clinically healthy psittacine birds. *Bacteroides clostridiiforme* was found from 1 of 69 isolates (Bangert 1988)

4. Normal Flora of Insectivorous and Carnivorous Birds

A. Gram negative coliforms
B. Ramphastidae (Toucans, toucanets, and aracaris)
    i. *E. coli* and *Klebsiella* spp. are not uncommon isolates from the digestive tract. Better able to handle their Gram negative bacteria than psittacine birds.

5. Abnormal Flora

A. Primary or Secondary pathogens
    i. Mostly Gram negative bacteria
    ii. A few Gram positive bacteria
        a. Genera *Mycobacterium, Staphylococcus*, and *Enterococcus*.
    iii. Autochthonous flora in unusual places

6. Diagnosing Bacterial Infections

A. By culture!!
    i. Almost uniform culture (>80%)
B. Evidence of host inflammatory response
    i. Cytology
        a. Increased number inflammatory cells
        b. Phagocytized bacteria
    ii. CBC; Toxic changes to heterophils
    iii. Protein electrophoresis

7. Important to determine primary vs. secondary infections

A. Secondary are able to maintain a disease process
B. Laboratory testing rarely helpful in differentiating
C. Many times, diagnosis of a primary infection is based on the exclusion of other diseases

8. Secondary Bacterial Pathogens

A. Had help breaching the body's defenses
    i. Autochthonous flora in abnormal sites
    ii. Mixed cultures from flock isolations
    iii. Isolated a concurrent virus or chlamydophila
    iv. Identification of predisposing factors
        a. Vitamin A, tumours
B. Treatment of such agents does not always restore health

9. Primary Bacterial Pathogens

A. No other microbes identified
    i. Viral, *Chlamydophila* spp., other bacteria
B. Isolation of concurrent protozoa or fungi

C. Cause a specific disease that can be reproduced experimentally

10. Host Range

A. *Salmonella* sp.
   i. Host adapted chicken strains: S. pullorum and S. gallinarum
B. *Avibacterium paragallinarum* (*Haemophilus paragallinarum)* (infectious coryza)
   i. Chickens, acute upper respiratory tract infection
C. *Mycobacterium sp* and *Yersinia pseudotuberculosis*
   i. Zoonotic

11. Clinical Signs

A. Usually non-specific
   i. Highly pathogenic bacteria or severely compromised host
      a. Septicaemic and acute death
   ii. Chronic
      a. Depends on site
      b. Sick bird signs

12. Collection Sites

A. Upper respiratory tract
B. Gastrointestinal tract
C. Joint/bone
D. Trachea, lungs, Air sacs
E. 'Abscess'

13. Therapy and Control

A. Antimicrobials
   i. Aminoglycosides orally; NOT absorbed systemically
   ii. Klebsiella spp. are resistant to penicillins such as Zosyn (a piperacillin/tazobactam combination injectable)
B. Environment
C. Predisposing factors

14. Bacteria of Concern

A. *Escherichia coli*
B. *Klebsiella* spp.
C. *Salmonella spp.*
D. *Acinetobacter baumannii*
E. *Listeria monocytogenes*
F. *Pasteurella spp.*
G. *Pseudomonas spp.*
H. *Staphylococcus spp.*
I. Mycobacteria
J. Toxin producers
K. Spiral bacteria

15. The family Enterobacteriaceae

A. Members may be normal if isolated from gastrointestinal tract, not normal if isolated from respiratory or reproductive tracts
B. A large group of Gram-negative rods
    i. Facultative anaerobes and non-spore forming
    ii. Includes *Escherichia coli* and Genera *Klebsiella, Salmonella, Shigella, Enterobacter, Yersinia, Serratia, Proteus, Morganella*, and *Citrobacter*
C. Other Family members
    i. Infrequent isolates
        a. *Serratia marcescans*
            * Associated with chronic debilitating diseases
            * Low pathogenicity
        b. *Proteus* sp.
            * Low pathogenicity
            * One survey isolated from parrots with respiratory disease
        c. *Citrobacter* sp.
            * GI disease
    ii. Frequent isolate
        a. *Enterobacter sp*.
            * Low pathogenicity
            * Needs a compromised host
            * *Enterobacter agglomerans* is a common isolate from sunflower seeds
            * Is not associated with disease outbreaks (Benskin 2009)

16. *Escherichia coli*

A. Important avian pathogen, very common
    i. Gram negative, nonspore forming bacillus
B. Extremely pathogenic to non-pathogenic
    i. Mammalian virulence factors not applicable to avian strains
    ii. Avian *E. coli* produce few exotoxins compared to those from mammals
    iii. Common isolate from asymptomatic cockatoos and apparently healthy passerine birds and waterfowl (Benskin 2009).
C. Transmission: all routes
D. Disease
    i. Pneumonia, hepatitis, enteritis, septicaemia, infertility, sinusitis, ingluvitis
    ii. Coligranulomatosis in Phasianidae; pheasant family (Galliformes order)
        a. Chickens, turkeys, peafowl, partridges
    iii. A very important cause of enteritis and death in nestling canaries and finches

17. *Klebsiella* sp.

A. Mucoid Capsule provides protection from environment and disinfectants
    i. Gram negative coccobacillus
B. Respiratory and enteric pathogen
    i. In the literature there are references as to it being associated with renal disease after septicaemia. May be true, however most studies show disease

of the respiratory and gastrointestinal tracts

C. Transmission: unknown
    i. Although one study showed oral inoculation resulted in disease in budgerigars

18. *Salmonella* spp.

A. Most important is *Salmonella enterica* serotype typhimurium
    i. Most frequent isolate from psittacine and wild birds (Subgenus I) (Benskin 2009)
    ii. Host adapted strains
        a. Chickens
            i. Maybe pigeons and European Finches
        b. Results in asymptomatic carriers
    iii. Carriers
    iv. Transmission: usually oral
        a. Sources are other birds, rodents, flies, other vectors

B. The disease
    i. Peracute, acute, chronic, subclinical
        a. Clinical signs: lethargy, fluffed, remain near feeding areas but seem unable to swallow.
    ii. Classic gross lesions: hepatomegaly, splenomegaly, pneumonia, and enteritis

C. Psittacine birds: Low prevalence 2-9%
    i. May be a possible higher prevalence in Congo African Grey
    ii In a recent study, Salmonella serogroup B, was isolated via faecal culture at 1.63% (3 of 185) and by PCR at 2.7% (Sareyyupoglu, 2008)

D. Treatment?
    i. Zoonotic

19. *Acinetobacter baumannii*

A. Strictly aerobic, Gram negative rod

B. Gaining prominence in the realm of human infections due to its ability to develop multidrug-resistance
    i. A rare isolate from avian species.
    ii. From a survey of bacterial and fungal isolates in psittacine birds, *Acinetobacter* sp. were identified in 12.5% of faecal samples and 6% of necropsies, mostly as part of mixed cultures and predominantly in large parrots. (Dorrestein 1985)
    iii. *Acinetobacter baumannii* was isolated from a localized cutaneous *Mycobacterium* spp. infection in thirteen falcons (Muller 2010)

20. *Listeria monocytogenes*

A. Gram positive rod

B. Ubiquitous in the environment
    i. Faeces, soil, water, and decaying plant material are common sources

C. Infections in birds
    i. Reported in a variety of birds, including chickens, turkeys, pigeons, ducks,

geese, raptors, peafowl, parrots, and canaries
    a. Rare in pet birds (Shivaprasad 2007, Akanbi 2008)
ii. Typically multi-organ inflammation is associated with the bacteria (septicaemia)
    a. Heart and brain involvement is seen in poultry
iii. The differentials for the multiple pyogranulomatous to granulomatous lesions are: mycobacteriosis, yersiniosis, coligranulomatosis, or fungal infections

D. Infections in people
i. Humans commonly ingest *Listeria* sp contained in raw and unprocessed food products (poultry).
ii. The symptoms of human listeriosis include muscle aches, neck stiffness and convulsions, and can result in gastroenteritis, miscarriage

21. *Pasteurella spp.*

A. Bipolar staining rods
i. Several somatic serotypes

B. *P. multocida*
i. Avian Cholera of poultry and waterfowl
    a. Septicaemia with high morbidity and mortality
    b. *P. multocida* belonging to somatic serotype 1 and capsular type A has been known to cause avian cholera in domestic poultry
ii. Cat bite septicaemia
    a. Pet birds
    b. Also bites of rat and mouse
    c. Acute septicaemia
    d. Need aggressive therapy
    e. *Pasteurella* somatic serotype 3 commonly isolated from psittacine birds caught by cats
iii. Raptors
    a. Besides septicaemia-related lesions, a unique syndrome of oesophageal abscesses was noted in Buteo hawks *(Buteo jamaicensis*) that succumbed to avian cholera.
    b. Oesophageal abscesses were not noted in birds belonging to the order Strigiformes (owls) or family Falconidae (falcons and their relatives).

22. *Pseudomonas* spp.

A. Opportunistic
i. Associated with prolonged antibiotics, immunosuppression, vitamin A deficiency and mucosal damage
ii. Non-enteric, Gram-negative bacteria

B. Disease
i. Associated with upper respiratory infections in psittacine birds
ii. Enteritis, airsacculitis, and infections of the orophaynx in finches and canaries

C. Contaminated water is common source
i. Can survive in medical iodine solutions
ii. Secretes a protective biofilm

D. *P. aeruginosa* often highly resistant to antibiotics
    i. Bluish green pigment and sweetish odor
E. Treatment
    i. Aggressive
    ii. Combination antibiotics

23. *Staphylococcus spp.*

A. Gram positive coccus
B. Most are normal flora or non-pathogenic
    i. *S. aureus* most pathogenic
        a. Uncommon 'normal' isolate from choana/cloaca and uropygial gland (Briscoe 2009a)
        b. Treat if clinical signs
        c. Methicillin-resistant S. aureus has been recovered from a pet bird with skin lesions (Briscoe 2009)
        * Australian veterinarians with dogs and cats as a major activity had a 4.9% prevalence of MRSA carriage (Jordan 2011)
    ii. From a recent study of *Staphylococcus* isolates from choana/cloaca and uropygial gland (Briscoe 2009a)
        a. In the sanctuary birds (limited human contact), 35% had positive culture results.
    iii. *S. sciuri* and *S. intermedius* were the most common isolates
        b. Pet birds; 71.2% of the birds had positive culture results.
    iv. The most common isolates from pet birds were *S. hominis*, *S. epidermidis*, *S. capitis*, *and S. haemolyticus*
        a. All species known to colonize humans
        c. Cockatoos were twice as likely to have positive results for staphylococci as were other genera.
C. Wound infections common
    i. Bumblefoot

24. ***Enterococcus faecalis* (formerly *Streptococcus faecalis*, 1990)**

A. Part of intestinal flora of many mammals and poultry
    i. A Gram positive coccus
    ii. Isolates appear to be highly resistant to many commonly used antibiotics
B. Causes a tracheitis, pneumonia and/or airsacculitis of canaries and finches
    i. Clinical signs are the same as pox virus infection and *Sternostoma* mite infestation
        a. Increased respiratory sounds, voice changes, dyspnoea

25. Mycobacteria

A. Gram positive, acid fast
B. *M. avium* most common although *M. geneviese* is frequently recognized
    i. Usually wasting disease
    ii. Granulomas to diffuse lesions
    iii. Sometimes skin lesions (mostly *M. tuberculosis*)

iv. Conjunctivitis in cockatiels

C. Diagnosis
  i. Acid Fast stains
    a. Liver, bone marrow, intestinal mucosal aspirates
  ii. Haematology
  iii. Biopsy
  iv PCR tests

D. Zoonotic

E. Transmission: faecal-oral
  i. Very stable in environment

26. Toxin Producers

A. Multiply in host and produce a toxin
  i. *Clostridium perfringens*
    a. Divided into 5 types (A, B, C, D, and E) based on production of four major toxins (alpha, beta, episilon, and iota). All types produce enterotoxin (CPE) and *C. perfringens* β2 toxin (CPB2)
  ii. From birds: Type A, toxin alpha (Crespo 2007)
    b. Most commonly identified in lorys and lorikeets
    c. Source is contaminated food
  iii. Clinical signs: haemorrhagic droppings
  iv. Gross: mucosal hemorrhage in ventriculus and intestines
  v. Histology: Ulcerative and necrotizing enteritis with large Gram positive rods
  vi. *E. coli* (see previous notes)

B. The bacterial toxin is ingested
  i. *Clostridium botulinum* produces a toxin that is ingested and results in clinical signs
  a. There are seven distinct types of toxin, designated A-G of which almost all birds are susceptible to type C botulism, though waterfowl and shorebirds are most notably affected
  b. Among waterbirds, such as gulls, loons and grebes, outbreaks have been caused by type E toxin, probably as a result of ingestion of toxic fish

27. Spiral Bacteria

A. Associated with clinical and subclinical upper respiratory tract and oral cavity infections in young cockatiels (< 2years) and rarely lovebirds (Evans 2008)

B. Clinical signs
  i. Reddened nares, choana and choanal papilla, and pharynx
  II. Less common: conjunctivitis, sinusitis, periorbital swelling, lethargy, anorexia

C. Diagnosis
  i. Cytology
    a. Spirally curved, motile, Gram negative rod
  ii. Culture has been unsuccessful to date
  iii. PCR suggests it belongs to the genus Helicobacter

D. Treatment
  i. Doxycycline at 400 mg/L drinking water X 30 days

28. Fungal Diseases

A. All difficult to diagnose and treat
    i. Except Candida
B. Host is frequently compromised
C. Fewer therapeutic agents compared to bacterial therapy

29. *Aspergillus* spp.

A. Ubiquitous and opportunistic
B. Respiratory tract infections
    i. Disease depends on chronicity, the organ system involved, and number of spores
    ii. Acute
        a. Overwhelming spores
        b. Showers the lungs and airsacs
    iii. Chronic respiratory
        a. Common in caudal thoracic and abdominal airsacs
            * psittacine birds, penguins, and large falcons
        b. More lung involvement than airsac
            * Various hawks, owl, eagles, swans, arctic waterfowl, and Galliformes
        c. Very extensive disease before clinical signs
    iv. Localized granulomas of sinuses, trachea, internal locations
        a. Syrinx common location
C. Diagnosis
    i. High index of suspicion
    ii. Haematology
        a. Leukocytosis, heterophilia, monocytosis, increase in some enzymes (CPK, LDH, SGOT), nonregenerative anemia, elevated total protein
    iii. Radiology
        a. Air sac hyperinflation, nodules in air sacs and lungs
    iv. Serology
        a. ELISA serology tests
        b. Plasma assay to measure galactomannan, an *Aspergillus* antigen (Cray 2009)

30. *Candida* spp.

A. Normal flora
    i. Disease is almost always secondary or tertiary
        a. Not uncommon after one-two weeks of broad spectrum antibiotics
        b. Malnutrition, stressful environment, co-existing infections
B. Digestive tract infections--most common
    i. Ingluvies number one
        a. Get stasis then overgrowth
    ii. Hyphal form can indicate disease--invasion
    iii. Pseudomembranous patches of necrotic material on mucosa

C. Has also been identified as cutaneous, venereal and systemic infections

31. *Cryptococcus* spp.

A. Yeast-like
   i. Grows poorly at >40°C
   ii. Narrow budding thick capsule
B. Zoonotic
   i. Usually associated with bird droppings
      a. Poultry and pigeons
      b. Other birds can be a source (Lugarini 2008).
C. *C. neoformans* (*var neoformans* and *var grubii*) and *C. gattii* (formerly *C. neoformans var gattii*) are two closely related siblings and are the primary pathogenic species.
D. Five main serotypes (Lucas, 2010).
   i. vars *neoformans* and *grubii* have been classified into three serotypes: A and D are assigned to *C. neoformans var. grubii and C. neoformans var. neoformans*, respectively; serotype AD strains are hybrids.
      a. Commonly associated with bird droppings and soil where potential bird carriers such as pigeon nests
         i. Serotypes B and C are considered to belong to *C. gattii*.
         ii. Associated with soil and vegetation around *Eucalyptus camaldulensis* trees
         iii. PCR testing of passerine and psittacine faeces identified *Cryptococcus neoformans var. grubii* most commonly and rarely *C. gattii* from collections in Brazil (Lugarini 2008)
D. Rare infections in birds
   i. Develops a myxomatous gelatinous mass and involves the CNS and respiratory tract
   ii. Upper respiratory tract portal of infection due to lower temperature?
   iii. In most avian cases, the birds usually had been on antibiotics
E. Clinical signs
   i. Depression, weakness, anorexia, weight loss, acute diarrhea, incoordination, blindness, dyspnoea, nasal exudate, soft tissue swelling, oral masses, death
F. Diagnosis
   i. Cytology; budding yeast with thick capsule
      a. India ink to demonstrate the capsule
   ii. Culture; grows on commonly used media

32. Endoventricular mycosis

A. Most commonly of the ventricular koilin in finch and finch-like birds
   i. The yeast organisms proliferating within the koilin of the ventriculus are most likely *Candida* spp., although cultures would be necessary for a definitive diagnosis.
B. Clinical signs
   i. Range from unexpected death to weight loss and passing intact seeds in their droppings.
C. Predisposing factors

i. Various conditions such as recent shipping, crowded housing, reproductive activities, and mixed species aviaries are common recent stresses. Although antibiotic therapy is typically associated with secondary yeast infections, this is not a frequently reported occurrence with endoventricular mycosis.

D. Diagnosis
   i. As all cases have been necropsy findings, diagnosis and therapy in the live bird is not reported.

33. Megabacteria (aka gastric yeast)

A. Large, variably Gram-positive rods
   i. Now known to be fungal organisms, *Macrorhabdus ornithogaster*
B. Found in glands of the proventriculus
   i. Small birds: budgies, parrotlets, lovebirds, cockatiels, finches, canaries
      a. Rare in larger psittacine birds
   ii. Clinical sign; weight loss
C. Diagnosis
   i. Unstained wet mounts of feaces
      a. Easily identified with calcoflour white M2R, but testing not commonly available.
   ii. Faecal Gram stains
      a. Stains poorly Gram positive
   iii. Radiographs; hour-glass constriction proventriculus and ventriculus
D. Treatment uncertain
   i. Amphotericin B
   ii. Gastric acidifying agents ineffective in controlled studies

34. *Malassezia* sp.

A. Commensal yeast found in the ears of dogs and cats
B. Associated with hyperkeratosis and folliculitis in psittacine birds
   i. Diagnosis by biopsy and histopathology
C. One case of isolation of this organism from the mucus membranes of the crop (scarlet macaw)
   i. Treatment of primary infections cleared the *Malassezia* spp. infection.
D. A recent skin case was identified as *Malassezia slooffiae*
   i. Found in the superficial epithelial and follicular keratin

35. Zygomycetes

A. Common lab contaminants
B. *Rhizopus, Mucor, Absidia* spp.
C. Usually respiratory lesions or fungal granulomas of the digestive tract
   i. Respiratory lesions look like aspergillus pneumonias
   ii. Gastric fungal lesions
      a. Usually young (< 1 year), large psittacine birds or older 'polypharmacy' birds
      b. Lesion is a severe transmural infection
D. Need to culture to identify

36. Selected Post mortem cultures isolates (2003-2008) on young (<1 year) psittacine birds (n=76 from ZEPS files) (* indicates association with the lesions by histology)

A. Isolates from airsacs
*Staphylococcus**, *Streptococcus**, *Enterococcus faecalis**

B. Isolates from Lung
*Enterobacter agglomerans**, *Klebsiella pneumoniae**, *Streptococcus* spp., *E. coli**, *Corynebacterium* spp., *Bacillus* spp., *Aspergillus* spp.*

C. Isolates from Nasal Sinus
*Staphylococcus aureus**, *Pseudomonas* spp.*, *Pasteurella* spp.*

D. Isolates from Crop
Candida spp.*, *Bacillus* spp., *E. coli*

E. Isolates from Proventriculus/Ventriculus
Mucor, Absidia or Rhizopus fungal groups*, megabacteria (avian gastric yeast)*, *Corynebacterium* spp., and *Streptococcus* spp.

F. Isolates from Intestines
Enterobacter cloacae, *Enterobacter agglomerans*, *E. coli**, *Edwardsiella tarda**, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Citrobacter freundii**, *Acinetobacter lwoffi**, *Streptococcus* spp.*, *Bacillus* spp., and *Staphylococcus* spp.

G. Isolates from Liver
Klebsiella pneumoniae, Enterobacter cloacae, Enterobacter sakazahki, Enterobacter gergoviae, *Enterobacter agglomerans*, Enterobacter aerogenes*, Acinetobacter baumanni*, Acinetobacter lwoffi, Acinetobacter calcoaceticus*, Alcaligenes faecalis, E. coli**, *Pseudomonas* spp.*, *Morganella morganii, Serratia rubidaea*, *Staphylococcus* spp.*, *Streptococcus* spp.*, and *Bacillus* spp.*

37. The State of Avian Bacterial Isolates 1992, Poster Presentation, Annual Conference of the Association of Avian Veterinarians

A. We examined 3,416 potential bacterial pathogens obtained via samples taken from the cloacal/faecal site or oral cavity of psittacine birds to determine if differences in antibiotic sensitivity patterns occurred across the nation.

B. Method. For purposes of this poster, we bypassed any attempt to correlate the culture site (oral, faecal, cloacal or combined source) and isolates or to differentiate bacteria isolated from clinically normal or ill birds. The study focused only on bacterial cultures from psittacine birds, and included the following species: African Greys, Amazons, brotogeris, budgerigars, cockatiels, cockatoos, conures, lories, lovebirds, macaws, parakeets, parrots, *Pionus* spp., and *Poicephalus* spp.

C. Bacterial Isolates
- i. *Acinetobacter* spp. (467)
- ii. *Citrobacter* spp. (197)
- iii. *E. coli* (556)
- iv. *Enterobacter* spp. (917)
- v. *Klebsiella* spp. (508)
- vi. *Pseudomonas* spp. (566)
- vii. *Serratia* spp. (157)

D. Antibiogram. The results are similar to a previous clinical report in 1985 when comparisons are possible. The methodologies for drug susceptibility testing differed in the two studies. The previous report was based on Kirby-Bauer sensitivity testing. This report was based on broth dilution technique, which tends to provide greater precision.

E. *Acinetobacter* spp.

i. History:

* When discovered in psittacine birds, these non-fermentative, oxidase-negative rods (found as a free-living ubiquitous saprophyte) have usually represented opportunistic pathogens. Routine testing isolated these bacteria on seeds, and detected them through samples taken from birds with sinusitis, vomiting/diarrhoea, pneumonia, and conjunctivitis. *Acinetobacter* spp are most commonly isolated with other Gram-negative bacteria.

ii. This Study:

Acinetobacter spp were the fifth most commonly isolated Gram-negative organisms. Many antimicrobials showed good efficacy toward these bacteria. The quinolones, aminoglycosides, and the newer generation penicillins represented excellent choices. Ampicillin, the cephalosporins, and trimethoprim/sulfa performed poorly.

F. ***Citrobacter* spp.**

i. History:

* A member of the Enterobacteriaceae group, it has proved to be a potential bacterial pathogen. *Citrobacter* spp have been isolated from psittacine cases of gastroenteritis, sepsis, and salpingitis.

ii. This Study:

* The organism ranked as the sixth most common isolate. The quinolones and the aminoglycosides were the antimicrobials of choice. *Citrobacter* spp. appeared to be fairly resistant to commonly available antimicrobials.

G. ***E. coli***

i. History:

* *E. coli*, one of the most common members of the Enterobacteriaceae family, has exhibited both pathogenic and non-pathogenic strains. It has been isolated from seeds, fruits, vegetables, bedding, litter, and from visibly clean water crocks. Clinical diseases in psittacine birds associated with this bacteria include rhinitis, sinusitis, otitis externa, air sacculitis, enteritis, septic arthritis, pneumonia, oophoritis, and chronic granulomas. From case reports it has appeared to be a common isolate from birds with papillomatosis. Species believed to be most susceptible include cockatoos, cockatiels, budgerigars, lories, and toucans. Other studies have suggested that cockatoos may normally carry *E. coli.*

ii. This Study:

* *E. coli* came in as the third most common isolate and seemed to be very susceptible to many antimicrobials. As with other Gram negative isolates, ampicillin and cephalothin were poor drug choices.

H. ***Enterobacter* spp.**

i. History:

* *Enterobacter* spp, opportunistic pathogens of the Enterobactericeae family, have been isolated from fruits and vegetables within hours of being offered for food. In one study, *Enterobacter agglomerans* appeared as the most frequently isolated Gram-negative on seeds. It has been associated with upper respiratory infections, diarrhea and enteritis in psittacine birds.

ii. This Study:

* The *Enterobacter* spp was number one of all the isolated Gram-negatives. Along with family members *Citrobacter*, *Serratia*, *E. coli*, and *Klebsiella*, the quinolones and aminogylcosides rendered the best antimicrobial benefit. piperacillin also performed favorably.

I. ***Klebsiella* spp.**

i. History:

*These bacteria are another common member of the Enterobacteriaceae family. *Klebsiella* spp are considered opportunistic pathogens which can be very difficult to eradicate because they have a capsule. They were associated with respiratory diseases.

ii. This Study:

* The quinolones and aminogylcosides again demonstrated excellent efficacy. Cefotaxime also presented a good choice. At the bottom end of the antibacterial spectrum, ampicillin, ticarcillin, cephalothin, and piperacillin should be avoided.

J. ***Serratia* spp.**

I. History:

*These Gram-negative Enterobacteriaceae are potential pathogens. They have been isolated from bedding, soil, and water. In isolated cases these bacteria have caused multiple subcutaneous abscesses and necrotizing pneumonia.

ii. This Study:

* *Serratia* spp comprised the seventh largest group of the Gram-negative isolates. As found with *Citrobacter*, *Enterobacter, E. coli*, and *Klebsiella*, the quinolones and aminoglycosides were the top antimicrobials. cephalothin, ampicillin, nitrofurantoin, and ticarcillin gave poor results.

K. ***Pseudomonas* spp.**

i. History:

* *Pseudomonas* spp are non-lactose fermenting Gram-negative bacteria. They are rarely isolated from healthy birds. *Pseudomonas* is considered a pathogen. The organisms have been isolated from bedding, seeds, fruits, standing water in hoses or pipes, and blenders for baby formulas. They are ubiquitous in the environment. Upper respiratory and digestive tract infections are the most common diseases caused by these bacteria. *Pseudomonas* spp. appear to frequently develop antimicrobial resistance which may contribute to the common treatment failures.

ii. This Study:

* *Pseudomonas* spp. made up the second most frequently isolated organisms. They also demonstrated a higher degree of antimicrobial resistance than any other group. As found with the other bacteria, the new quinolones and our

"old stand-bys" the aminoglycosides fared well. piperacillin also rated well.

L. Conclusions

1. Regardless of where you practice or where the bird lives, bacteria show similar drug sensitivities (antibiograms) across the North American continent.
2. Ampicillin, first-and second-generation cephalosporins, and Nitrofurantoin should not be used without bacterial sensitivities. Even then, other antimicrobials should be considered, as many avian Gram-negatives may readily pass resistance factors.
3. The quinolones (ciprofloxacin and norfloxacin), the aminoglycosides, and piperacillin are all excellent choices.

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