Compendium of Measures to Control Chlamydia psittaci Infection Among Humans (Psittacosis) and Pet Birds (Avian Chlamydiosis), 2017

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Special Report

Compendium of Measures to Control *Chlamydia psittaci* Infection Among Humans (Psittacosis) and Pet Birds (Avian Chlamydiosis), 2017

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On Behalf of the National Association of State Public Health Veterinarians *Chlamydia psittaci* Infection Among Humans (Psittacosis) and Pet Birds (Avian Chlamydiosis) Compendium Committee and Committee Consultants, 2017.

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Abstract: Psittacosis, also known as parrot fever and ornithosis, is a bacterial infection that can cause severe pneumonia and other serious health problems in humans. It is caused by *Chlamydia psittaci*. Reclassification of the order Chlamydiales in 1999 into 2 genera (*Chlamydia* and *Chlamydophila*) was not wholly accepted or adopted. This resulted in a reversion to the single, original genus *Chlamydia,* which now encompasses all 9 species including *Chlamydia psittaci*. During 2003–2014, 112 human cases of psittacosis were reported to the Centers for Disease Control and Prevention through the Nationally Notifiable Diseases Surveillance System. While many types of birds can be infected by *C psittaci*, in general, the literature suggests that human cases can most often occur after exposure to infected parrot-type birds kept as pets, especially cockatiels, parakeets, and conures. In birds, *C psittaci* infection is referred to as avian chlamydiosis. Infected birds shed the bacteria through feces and nasal discharges, and humans become infected from exposure to these materials. This compendium provides information about psittacosis and avian chlamydiosis to public health officials, physicians, veterinarians, the pet bird industry, and others concerned with controlling these diseases and protecting public health. The recommendations in this compendium provide standardized procedures to control *C psittaci* infections. This document will be reviewed and revised as necessary, and the most current version replaces all previous versions. This document was last revised in 2010. Major changes in this version include a recommendation for a shorter treatment time for birds with avian chlamydiosis, additional information about diagnostic testing, including genotyping, clearer language associated with personal protective equipment recommended for those caring for confirmed or exposed birds, and incorporating a grading scale with recommendations generally based on the United States Preventive Services Task Force's methods.

Key words: psittacosis, avian chlamydiosis, *Chlamydia psittaci*, compendium, avian, pet bird

Introduction

Chlamydia psittaci is a member of the family Chlamydiaceae.[1] To date, at least 8 serovars and 8 corresponding genotypes are well described.[2] Characterization of *C psittaci* to the genotype level from cultured isolates is important in our understanding of the epidemiology and clinical impact of this bacterium in animals and humans, and its application is encouraged, particularly in outbreak settings.[3–9] In some cases, these obligate intracellular bacteria can be transmitted from birds to humans; the resulting infection is referred to as psittacosis (also known as parrot fever and ornithosis). A range of clinical outcomes has been reported in association with human cases of psittacosis, from the more common subclinical or brief, self-limiting, influenza-like illness to the less commonly reported fulminant psittacosis with multi-organ failure.[3,10–13] With appropriate treatment, the infection is rarely fatal.

The most recent time period for which complete diagnostic and patient information, like exposure, is available on reported human cases is from 2006 to 2012. During this time period, 58 human cases of psittacosis were reported (mean 8.3/y, range 2–21/y) to the Centers for Disease Control and Prevention (CDC).[14] Of the 58 cases, specific diagnostic information was available for only 30, and of those, only 2 (7%) were confirmed by culture. For the remaining reports, diagnosis was based only on serologic testing, which lacks specificity and can be difficult to interpret. The above count may not be an accurate reflection of the actual number of human cases due to limited testing and inadequacies of historic diagnostic techniques. Newer diagnostic tests, such as real-time polymerase chain reaction (PCR), are now available, although within specialized laboratories. Trends in human psittacosis should therefore be interpreted with caution, taking into account limitations in public health surveillance discussed in more detail below.

Although other types of exposure resulting in illness have been reported, contact with birds appears to be the primary risk factor for illness.[10,11,15,16] Persons at greatest risk include those exposed to birds via recreational or occupational exposure, such as pet bird owners and breeders, pet shop employees, zoo employees, poultry workers, veterinarians, diagnostic laboratorians, and wildlife workers.[3,12,17–35] Because not all patients recall avian exposure, *C psittaci* should be considered in patients with clinically compatible symptoms. For instance, of the 26 cases reported during 2006–2012 where exposure was recorded, 19 (73%) reported avian exposure. In addition to transmission through direct contact with birds, particularly if the birds were ill or recently acquired, human infection can also result from indirect environmental exposure.[6,12,21,28,36–48]

In this compendium, *C psittaci* infection in birds is referred to as avian chlamydiosis. Chlamydial organisms have been isolated from more than 460 bird species from 30 orders[49] but are most commonly identified in psittacine (parrot-type) birds, especially cockatiels and budgerigars (also called parakeets or budgies). Among nonpsittacine birds, infection with *C psittaci* occurs most frequently in pigeons and doves.[11,49,50] Among poultry species, occupational illness has been associated with turkeys in the United States and other countries, as well as chickens and ducks in Europe.[7,8,24,29] Avian chlamydiosis can occur in birds in the scientific order Passeriformes, such as canaries and finches, but is less frequently diagnosed.[11,12,49,51–53]

Purpose and Methodology

The recommendations in this compendium provide standardized procedures for managing avian chlamydiosis in the pet bird population, which is an essential step in efforts to reduce psittacosis among humans. Additionally, this compendium offers information and guidance regarding human illness, including diagnosis and treatment. This compendium is intended to guide public health officials, physicians, veterinarians, the pet bird industry, and others concerned with the control of *C psittaci* infection and the protection of public health.

To identify relevant literature, a comprehensive search of PubMed was performed by using various combinations of search terms including, but not limited to: psittacosis, *Chlamydia psittaci*, *Chlamydophila psittaci*, *C. psittaci*, pneumonia, ornithosis, respiratory, human, diagnosis, testing, treatment, pet bird, wild bird, and avian. Relevant literature was also obtained through reviewing the references of papers identified by the PubMed search, as well as references put forward by members of and consultants to the compendium committee. With one exception, only English-language manuscripts that were available via an online source were reviewed, but no restriction was placed on year of publication. An article was included as a reference to support specific information or recommendations if its content aligned with the purpose of the compendium. Additional references and resources were identified via the websites of public health agencies, such as the CDC and state health departments, academic institutions, labor agencies (eg, Occupational Safety and Health Administration), and animal health agencies (eg, United States Department of Agriculture).

Each of the overarching recommendations for controlling infections in humans and birds (part III) has been assigned a level of evidence, using the level of evidence scale developed by the United States Preventive Services Task Force (USPSTF) as a general framework, to assist the reader in assessing the body of literature available to support the recommendation.[54] The committee identified articles relevant to each recommendation and then categorized each by study type: randomized controlled trial, systematic review, cohort study, case-control study, case series, and case report. The committee then further categorized each article in accordance with a USPSTF hierarchy of research design.[55] An aggregate level of evidence, generally based on the guidance developed by the USPSTF combined with the committee's judgment, was then assigned to each recommendation as varying levels of evidence are associated with the literature used to support each recommendation (Table 1). Levels of evidence assigned did not include an assessment of economic impact of a recommendation or economic impact of harm done by a recommendation, as very little literature in regard to psittacosis prevention measures in these areas could be found.

Part I. Infection in Humans (Psittacosis)

Limitations of human psittacosis surveillance

While psittacosis is a nationally notifiable disease, a number of factors might limit completeness of reporting and thus impact our understanding of epidemiological risk factors and trends in disease incidence (eg, by race and other demographic factors). Human illness with *C psittaci* is uncommonly reported, and complete patient information is not always available. Clinical differentiation of illness caused by *C psittaci* and illness caused by the more common human pathogen *Chlamydia pneumoniae* can be difficult. Additionally, infections resulting in milder illnesses might not be recognized and reported to public health authorities. Moreover, until recently, the diagnostic tests, such as serology, available for *C psittaci* displayed cross-reactivity with other *Chlamydia* spp; therefore, clinical reports in which serology alone is used as the basis for a diagnosis should be interpreted with caution.[10,56] To improve the quality and completeness of public health surveillance data, human healthcare personnel are encouraged to contact public health authorities early to discuss diagnostic options when psittacosis is being considered in the differential diagnosis for a patient being evaluated, and public health author-

Table 1. Recommendation grades associated with supporting evidence.

Recommendation	Supporting evidence	Grade[a]
Educate persons at risk and healthcare providers about psittacosis	7, 8, 12, 13, 18, 19, 21–27, 29, 30, 36, 39, 42, 48, 56, 59, 100, 108–114	B
Reduce risk of human infection when caring for ill or exposed birds	6, 18–20, 29, 33, 44, 56, 99, 110, 111, 115, 116	B
Maintain accurate records of all bird-related transactions for at least 1 year to aid in identifying sources of infected birds and potentially exposed persons	3, 28, 110, 117	B
Avoid purchasing or selling birds that have signs consistent with avian chlamydiosis	7, 110	C
Avoid mixing birds from multiple sources	3, 19, 27, 53, 100, 118	B
Quarantine newly acquired or exposed birds and isolate ill birds	7, 19, 99, 110, 112, 118	A
Test birds before they are to be boarded or sold on consignment	3, 119	B
Screen birds with frequent public contact	19, 119	B
Practice preventive husbandry	7, 19, 24, 27, 29, 48, 53, 99, 100, 110	B
Control transmission from infected and exposed birds	19, 27, 53, 110, 115, 118, 120	B
Use disinfection measures	11, 25, 27, 29, 99, 118, 120	A

[a] A: The committee strongly recommends the routine use of this prevention measure because there is good evidence from well-designed studies that it improves health outcomes and because the magnitude of its net benefit is substantial. B: The committee recommends the routine use of this prevention measure because there is at least fair evidence from studies that it contributes to an improvement in health outcomes or it is reasonable to assume that if this prevention measure was not in place health outcomes would suffer as a result and because the magnitude of its net benefits outweighs harms. C: The committee recommends the routine use of this prevention measure because it may contribute to an improvement in health outcomes, seems to be a reasonable prevention measure to employ, and is thought unlikely to do harm, although the evidence for this recommendation is based largely on a combination of opinions of respected authorities, clinical experience, case reports, or reports of expert committees.

ities are encouraged to gather comprehensive case information as guided by the Psittacosis Case Report Form available at http://www.nasphv.org/documentsCompendiaPsittacosis.html.

Transmission

The disease resulting from *C psittaci* infection in humans is called psittacosis. Most infections are acquired from exposure to psittacine birds, although transmission has also been documented from poultry and free-ranging birds, including doves, pigeons, birds of prey, and shorebirds.[18,46,47,57–59] Human infection with *C psittaci* usually occurs when a person inhales organisms that have been aerosolized from dried feces or respiratory tract secretions of infected birds. Other means of exposure include mouth-to-beak contact and handling of infected birds' plumage and tissues. Because not all patients report avian exposure, *C psittaci* infection should be considered in patients with clinically compatible symptoms. Based on the small number of cases that were reported to the CDC during 2003–2014, the main age group affected includes persons aged 40–64 years; however, it is unclear whether this is because of age-related differences in susceptibility or exposure.[60] *Chlamydia psittaci* is a rarely reported etiology of pneumonia and, based on reports in current literature, seems to account for very few cases of pneumonia requiring hospitalization.[10,61–65] *Chlamydia psittaci* has not been reported to be among the bacterial infections more commonly diagnosed in patients with human immunodeficiency virus, and currently, pet birds are thought to pose a low risk to the health of immunocompromised persons.[66,67] Case reports of adverse pregnancy outcomes associated with psittacosis infection during pregnancy have been published; diagnosis of *C psittaci* infection in these cases was primarily based on serologic testing.[68–70]

Person-to-person transmission of psittacosis is possible but thought to be rare.[71–74] Standard infection-control precautions are typically sufficient for the medical management of humans with psittacosis, and specific isolation procedures (eg, private room, negative pressure air flow, masks) are not indicated, unless there is evidence of person-to-person transmission.[15,72–75] Currently, there is no recommendation for droplet precau-

tions. If there is evidence of person-to-person transmission, the local and/or state health department should be contacted for further guidance.

Other potential modes of transmission, such as exposure to urban pigeon colonies, have been reported but appear to be uncommon.[42–47]

Clinical signs and symptoms

The onset of illness typically follows an incubation period of 5–14 days, but, historically, longer periods have been reported based on the results of serologic testing.[76] The severity of the disease ranges from a mild, nonspecific illness to a systemic illness with severe pneumonia and, rarely, death.[3,10,32,37] Before antimicrobial agents were available, 15%–20% of humans with respiratory infections with *Chlamydia* species infection died;[77] however, mortality has been extremely rare since the advent of antibiotics. Humans with symptomatic infections typically have an abrupt onset of fever, chills, headache, malaise, and myalgia. A nonproductive cough is usually present and can be accompanied by breathing difficulty or chest tightness. A pulse-temperature dissociation (fever without increased pulse rate), enlarged spleen, or nonspecific rash is sometimes observed. Auscultatory findings may underestimate the extent of pulmonary involvement. Radiographic findings may include lobar or interstitial infiltrates. The differential diagnosis of *C psittaci* pneumonia includes infection with *Coxiella burnetii, Histoplasma capsulatum*, *Mycoplasma pneumoniae*, *Legionella* species, *C pneumoniae*, and respiratory viruses such as influenza. Infection with *C psittaci* has been reported to affect organ systems other than the respiratory tract, resulting in conditions including endocarditis, myocarditis, hepatitis, arthritis, keratoconjunctivitis, encephalitis, and ocular adnexal lymphoma.[10,15,56,78–84]

Case definition for public health surveillance

CDC and the Council of State and Territorial Epidemiologists have established national case definitions for epidemiologic surveillance of psittacosis (available at https://wwwn.cdc.gov/nndss/conditions/psittacosis/case-definition/2010/). These case classifications should not be used as the sole criteria for establishing a clinical diagnosis or determining medical management. Please refer to the diagnosis section for further information about diagnostic test interpretation and limitations.

Diagnosis

Historically, diagnoses have been established based on clinical presentation and a positive serological result using microimmunofluorescence (MIF) with paired sera. While the MIF is generally more sensitive and specific than complement fixation (CF) tests,[85] the test still displays cross-reactivity with other *Chlamydia* species in some instances. Because of this, a titer less than 1:128 should be interpreted with caution, and true acute (obtained as close to the onset of symptoms) and convalescent (ideally taken 2–4 weeks later) specimen tests are required for proper interpretation. Additionally, if antimicrobial therapy has been initiated, antibody responses may be delayed or diminished such that a third serum specimen taken 4–6 weeks after the acute specimen should be considered. All serologic testing should be done simultaneously within a single laboratory to ensure consistency of results. Although serologic testing is more commonly used and available than molecular testing, results can often be ambiguous, subjective in their interpretation, and misleading due to inherent limitations of this approach. If possible, serology should be considered a supportive test that augments the findings of other more reliable assays, such as nucleic acid–based tests.[86]

More recently, molecular testing involving nucleic acid amplification, such as PCR, has increased in both reliability and availability.[8,20,48,87,88] Real-time PCR assays are now available within specialized laboratories (Table 2). These tests can be run on respiratory specimens, blood, and tissues, if warranted. In addition to being highly sensitive and specific for *C psittaci,* nucleic acid–based tests can provide capacity for strain genotyping. Because proper sample collection techniques and handling are critical to obtain accurate test results, clinical laboratories performing these tests should be contacted directly for specifics on specimen submission (Table 2). Currently, PCR testing is not Clinical Laboratory Improvement Amendments validated. Diagnostic tests should always be interpreted in light of a patient's history, clinical presentation, and response to treatment.

Chlamydia psittaci can also be isolated from the patient's sputum, pleural fluid, or clotted blood during acute illness and before treatment with antimicrobial agents; however, culture is performed by few laboratories because of the technical difficulty and occupational safety concerns associated with handling human tissues and fluids that may contain a biosafety level 3 pathogen such as *C*

Table 2. Laboratories that test human specimens for *Chlamydia psittaci*.

Laboratory	Tests performed	Telephone number/web site
Focus Diagnostics Inc (Quest subsidiary), Cypress, CA, USA[a]	MIF (IgM, IgA, IgG)	(800) 445-4032 www.focusdx.com
Laboratory Corporation of America, Burlington, NC, USA[a]	Culture, MIF (IgM, IgG)	(800) 222-7566 www.labcorp.com
Quest Diagnostics Nichols Institute, Valencia, CA, USA[a]	IFA (IgM, IgG, IgA)	(800) 421-4449 www.specialtylabs.com
Pneumonia Response and Surveillance Laboratory, Respiratory Diseases Branch, CDC, Atlanta, GA, USA[ab]	PCR, culture, genotyping (multiple specimen types)	(404) 639-4921 http://www.cdc.gov/laboratory/specimen-submission/detail.html?CDCTestCode=CDC-10153

Abbreviations: CDC indicates Centers for Disease Control; IFA, indirect fluorescence antibody; IgA, immunoglobulin A; IgG, immunoglobulin G; IgM, immunoglobulin M; MIF, microimmunofluorescence; PCR, polymerase chain reaction.

[a] During December 2015–May 2016, an internet search was performed, and individual laboratories were contacted to obtain information regarding the availability of the diagnostic tests.

[b] CDC is a reference laboratory, and samples must be submitted through state health departments. Some state public health laboratories may also offer testing.

psittaci.[89,90] Testing for *C psittaci* should include a swab of a respiratory specimen for PCR-based testing and culture. These samples should be submitted to specialized laboratories (Table 2).[87,91] Additionally, paired serum samples collected 2–4 weeks apart, ideally 21 days apart, should be evaluated at the same laboratory at the same time.

Laboratories that test human specimens for Chlamydiaceae

Information about laboratory testing is available from state public health departments. Human healthcare providers are encouraged to contact health department personnel early in the course of a patient's illness to discuss testing, particularly with regard to requesting PCR-based testing via CDC's Respiratory Diseases Division, and assistance with case investigation. Certain laboratories accept human specimens to confirm *C psittaci* infection through culture, MIF, or PCR (Table 2). Other sources not included in this table may also be available. Inclusion in Table 2 does not imply endorsement by the National Association of State Public Health Veterinarians or constituent institutions.

Treatment

Tetracycline antibiotics are the drug of choice for *C psittaci* infection in humans.[92] Typically, mild to moderate illnesses can be treated with oral doxycycline or tetracycline hydrochloride. Severely ill patients typically require treatment with intravenous (IV) doxycycline hyclate. Clinicians should consult a current formulary for drug doses and treatment length recommendations.[92,93] In addition, clinicians should consider consulting with an infectious disease specialist for guidance in regard to specific patient management. Most *C psittaci* infections are responsive to antibiotics within 1–2 days; however, relapses can occur. Although in vivo efficacy has not been determined, macrolide antibiotics are considered the best alternative agents in patients for whom tetracyclines are contraindicated. As has been proposed for the treatment of Rocky Mountain spotted fever, if the benefits outweigh the risks (especially if the alternative medicine is not effective and it is a life-threatening situation), a tetracycline, such as doxycycline, could be considered in children.[93–95] Prophylactic antibiotics are not routinely administered after a suspected exposure to *C psittaci* but may be considered in some circumstances.

Part II. Infection in Birds (Avian Chlamydiosis)

Transmission

Chlamydia psittaci may be excreted in ocular and nasal discharges and/or feces; shedding routes may vary by species.[11,96–98] The length of time a bird sheds the organism can also vary depending on the *Chlamydia* strain and host.[11,96,97] The organism is environmentally labile but can remain infectious for over a month if protected by organic debris (eg, litter and feces).[11,98,99] Some infected birds can appear healthy or have subtle clinical signs while shedding the organism.[98,99] Active disease can appear with no identifiable exposure or risk factor. Shedding can be exacerbated by stress factors, including reproductive activities,

rearing of young, relocation, shipping, crowding, injury, illness, and temperature extremes.[11,98–100]

Clinical signs

The usual incubation period of *C psittaci* infection ranges from 3 days to several weeks.[101,102] The severity of illness can range from subtle upper respiratory disease or mild conjunctivitis to death and depends on the virulence of the particular *Chlamydia* strain and the immune status of the host.[103] When clinical signs of avian chlamydiosis are apparent, they are nonspecific, may be subtle, and can include any or all of the following: lethargy, anorexia, ruffled feathers, conjunctivitis, ocular or nasal discharge or other clinical signs consistent with upper respiratory disease, diarrhea, and signs of liver disease such as excretion of green to yellow-green urates. Reproductive loss and neonatal death may occur in breeding birds. Whether the bird has acute or chronic signs of illness or dies depends on the species of bird, virulence of the strain, infectious dose, stress factors, age, and extent of treatment or prophylaxis.[11,98]

Case definitions

Veterinarians should contact their state's department of agriculture for guidance in regard to animal disease reporting.[104] The case definitions below are informed by the recommendations of the compendium's avian subject matter experts. See Appendix 1 for more information about diagnostic tests and test interpretation.

A confirmed case of avian chlamydial infection is defined on the basis of at least 1 of the following:

- Isolation of *C psittaci* from a clinical specimen.
- Identification of chlamydial DNA by use of in situ hybridization to detect chlamydial DNA followed by specific *C psittaci* DNA detection using PCR-based testing of in situ hybridization–positive tissues or secondary *C psittaci*–specific DNA probes in combination with characteristic pathology. The commercial antibodies used for immunohistochemistry staining cross-react with non-chlamydial epitopes and are not diagnostic.
- A fourfold or greater change in serologic titer in 2 specimens from the bird obtained at least 2 weeks apart and assayed simultaneously at the same laboratory.
- Identification of suggestive intracellular bacteria within diseased cells in smears or tissues (eg, liver, conjunctival, spleen, respiratory secretions) stained with Gimenez or Macchiavello stain in combination with detecting *C psittaci* DNA in the same tissue sample using a *C psittaci*–specific PCR-based detection assay.

A suspected case of avian chlamydial infection is defined as a compatible illness and at least 1 of the following:

- Identification of chlamydial nucleic acid by PCR-based testing in conjunctival, choanal, or cloacal swabs; blood; or feces.
- Chlamydiaceae antigen (fluorescent antibody) in feces, a cloacal swab specimen, or respiratory tract or ocular exudates. The commercial antibodies used for fluorescent antibody staining cross-react with non-chlamydial epitopes and are not diagnostic.
- Is epidemiologically linked to a confirmed case in a human or bird.

There may be cause for concern and further investigation if one of the following occurs: 1) identification of chlamydial nucleic acid by PCR-based testing in conjunctival, choanal, or cloacal swabs; blood; or feces in a healthy-appearing bird or 2) compatible illness with positive results from a nonstandardized test or a new investigational test.

Diagnosis

Several diagnostic methods are available to identify avian chlamydiosis in birds (see Appendix 1 for discussions of the advantages and limitations of the diagnostic tests available).

Treatment

Treatment should be supervised by a licensed veterinarian (see Appendix 2). The location for treatment should be discussed with the veterinarian and frequently is conducted on an outpatient basis.

Part III. Recommendations and Requirements

Recommendations for controlling infection among humans and birds

Aviary owners and owners of bird collections are encouraged to implement recommendations such as those described in the Model Aviculture Program.[105] Pet store owners are encouraged to implement recommendations such as those described by the Pet Industry Joint Advisory Council.[106] Managers of zoo bird collections are encouraged to implement recommendations of the Association of Zoos and Aquariums.[107] Such programs encourage disease prevention, discuss

basic husbandry, and improve animal health and the human-animal bond. To prevent transmission of *C psittaci* to humans and birds, specific measures are recommended and may be of help to public health officials and others concerned with the control of *C psittaci* infection:

Educate persons at risk and healthcare providers about psittacosis: Inform all persons in contact with birds or bird-contaminated materials about potential health risks. By the time infection is recognized in a group of birds, a critical period for pathogen accumulation and possible dissemination to humans and other birds has already occurred. Bird caretakers with respiratory or influenza-like symptoms should seek prompt medical attention and inform their healthcare providers about bird contact. Seeking healthcare early in the course of illness may improve clinical outcomes. Healthcare providers are encouraged to inquire about bird contact, particularly in cases of febrile respiratory illness where other, more common causes have been ruled out. Grade: B.*

Reduce risk of human infection when caring for ill or exposed birds: The prevalence of *C psittaci* in the well-managed pet bird population appears to be very low. However, any bird confirmed with avian chlamydiosis and any birds exposed (ie, within the same enclosure or air space) to confirmed avian cases should be managed using the following recommendations. When handling birds under these conditions or cleaning their cages, caretakers should wear protective clothing such as a smock or coveralls, gloves, eyewear, designated footwear or shoe covers, and a disposable surgical cap. A disposable particulate respirator (ie, a preshaped mask that molds firmly around the mouth and nose like an N95 or similar mask) should be worn. It is unknown if fit testing of a particulate respirator will offer additional protection. Surgical masks might not be effective in preventing transmission of *C psittaci*. Those who have an occupational exposure to birds should follow their facility's policies in regard to personal protective equipment use.

There is no documented transmission of *C psittaci* via ventilation systems from pet bird aviaries or pet stores to humans, nor are there any studies specific for *C psittaci* viability in these systems. In studies assessing *C pneumoniae,* an organism closely related to *C psittaci*, survival in aerosols at varying temperatures and humidity levels, *C pneumoniae* concentrations decreased significantly in a short period of time at moderate temperatures and humidity levels that may be expected for room air. Postmortem examinations of potentially infected birds should be performed in a biological safety cabinet. The carcass should be moistened with detergent and water to prevent aerosolization of infectious particles during the procedure. Grade: B.†

Maintain accurate records of all bird-related transactions for at least 1 year to aid in identifying sources of infected birds and potentially exposed persons: Records should include the date of purchase, species of birds purchased, individual bird identification, source of birds, and any identified illnesses or deaths among birds. Additionally, the seller should record the name, address, and telephone number of the customer and individual bird identification (eg, band or microchip number). Grade: B.[3,28,110,117]

Avoid purchasing or selling birds that have signs consistent with avian chlamydiosis: Signs are nonspecific and may include lethargy, ocular or nasal discharge, diarrhea, ruffled feathers, or low body weight. Grade: C.[7,110]

Avoid mixing birds from multiple sources: To prevent epornitics (ie, disease outbreaks in birds) and pathogen transmission to humans, additional control and prevention methods (eg, health screening, extended quarantine, *C psittaci* testing) may be required when birds from multiple sources are comingled. Grade: B.[3,19,27,53,110,118]

Quarantine newly acquired or exposed birds and isolate ill birds: Isolation should include housing in a separate air space from other birds and noncaretakers. Quarantine birds, including those that have been exposed to other birds at shows, exhibitions, fairs, and other events, for at least 30 days after the event and test before returning or adding them to a group. Grade: A.[7,19,99,110,112,118]

Birds of unknown C psittaci status should be tested before they are to be boarded or sold on consignment: House them in a room separate from other birds while test results are pending (see Appendix 1). Grade: B.[3,119]

Screen birds with frequent public contact (eg, bird encounters, long-term care facilities, schools):

Such testing may be used to reduce potential human exposure from birds. Specific protocols should be established in consultation with a qualified veterinarian, recognizing that many birds may demonstrate persistent immunoglobulin G (IgG) antibodies in the absence of active infection (see Appendix 1 for protocols). A negative *C psittaci* diagnostic test result does not guarantee that the bird is not infected. Grade: B.[19,119]

* *References 7, 8, 12, 13, 18, 19, 21–27, 29, 30, 36, 39, 42, 48, 56, 59, 100, 108–114.*

Practice preventive husbandry: Position cages to prevent the transfer of fecal matter, feathers, food, and other materials from one cage to another. Use substrate/litter that will not produce dust (eg, newspapers). Clean all cages, food bowls, and water bowls daily. Soiled bowls should be emptied, cleaned with soap and water, rinsed, placed in a disinfectant solution, and rinsed again before reuse. Between occupancies by different birds, cages should be thoroughly scrubbed with soap and water, disinfected, and rinsed in clean running water. Exhaust ventilation should be sufficient to prevent accumulation of aerosols and prevent cross-contamination of rooms. Grade: B.[‡]

Control transmission from infected and exposed birds through good husbandry: To prevent cross-contamination when caring for birds with avian chlamydiosis, birds should be cared for in the following order: healthy birds then exposed birds and then sick birds. Isolate birds requiring treatment. Rooms and cages where infected birds were housed should be cleaned and disinfected thoroughly after removal of infected birds. Workers should wear appropriate protective clothing (see "Reduce risk of human infection when caring for ill or exposed birds" above). When the cage is being disinfected, transfer the bird to a clean cage. Thoroughly scrub the soiled cage with a detergent to remove all fecal debris, rinse the cage, disinfect it (most disinfectants require 5–10 minutes of contact time), and rerinse the cage to remove the disinfectant. Discard all items that cannot be adequately disinfected (eg, wooden perches, ropes, nest material, substrate/litter). Minimize the circulation of feathers and dust by wet-mopping the floor frequently with disinfectants and preventing air currents and drafts within the area. Reduce contamination from dust by spraying the floor with a disinfectant or water before sweeping it. A vacuum cleaner or pressure washer may aerosolize infectious particles and should be used with caution. Frequently remove waste material from the cage (after misting the material with water), and burn or double-bag the waste for disposal. There is no documented transmission of *C psittaci* via ventilation systems from pet bird aviaries or pet stores to humans, nor are there any studies specific for *C psittaci* viability in these systems. Use of a high-efficiency particulate air filter on the air system return may be an option to reduce particulate matter in the air, but care should be taken when filters are changed. Grade: B.[§]

Use disinfection measures: All surfaces should be thoroughly cleaned of organic debris before disinfection. *Chlamydia psittaci* is susceptible to many disinfectants and detergents as well as heat; however, it is resistant to acid and alkali. Examples of effective disinfectants include 1:1000 dilution of quaternary ammonium compounds (eg, Roccal, Zephiran, Pet Focus), 1% Lysol, and freshly prepared 1:32 dilution of household bleach (one-half cup/gallon) or other oxidizing agents (eg, accelerated hydrogen peroxide–based disinfectant). Many disinfectants are respiratory irritants for both humans and birds and should be used in a well-ventilated area. Avoid mixing disinfectants with any other product. Grade: A.[11,25,27,29,99,118,120]

Recommendations for treating and caring for infected and exposed birds

Exposed birds not showing signs of illness should be isolated. Criteria for release from isolation should be established in consultation with a veterinarian (Appendix 1). Birds with confirmed or probable avian chlamydiosis should be isolated and treated under the supervision of a veterinarian (Appendix 2).

Responsibilities of bird owners, physicians, and veterinarians

Humans exposed to birds with avian chlamydiosis should seek medical attention if they develop influenza-like symptoms or other respiratory tract illnesses. Physicians should consider psittacosis in ill patients exposed to known infected birds or in those with compatible clinical illness when other etiologies have been excluded and collect human specimens for laboratory analysis if indicated. Psittacosis in humans is a nationally notifiable disease, and most states require physicians to report cases of psittacosis to the appropriate state or local public health authorities.[14,60] Treatment for psittacosis should be initiated as early in the clinical course of disease as possible. Timely diagnosis and reporting can help identify the source of exposure to *C psittaci*, thereby controlling infection spread. Local and state public and/or animal health authorities may conduct epidemiologic investigations and institute additional disease control measures. Birds that are suspected sources of human infection should be referred to veterinarians for evaluation and treatment.

Veterinarians should consider avian chlamydiosis in any lethargic bird that has nonspecific signs of illness, especially if the bird was recently purchased or stressed. If avian chlamydiosis is suspected, the veterinarian should submit appropriate laboratory specimens to confirm the diag-

nosis. Laboratories and attending veterinarians should follow local and state regulations or guidelines regarding case reporting. Veterinarians should report confirmed and probable cases of avian chlamydiosis and work closely with governmental authorities on investigations, as well as inform clients that infected birds should be isolated and treated. While reporting requirements will vary from state to state, the state public health veterinarian may serve as the initial point of contact for reporting.[121] Additionally, they should educate clients about the public health hazard posed by *C psittaci* and the appropriate precautions that should be taken to avoid the risk of disease transmission.

Local and state epidemiologic investigations

Local health authorities should report cases to their state health or agriculture department, as appropriate.[122,123] Because of the potential zoonotic nature of this pathogen, public health and animal health authorities may need to conduct cooperative epidemiologic investigations to control the transmission of *C psittaci* among humans and birds. An epidemiologic investigation should be initiated if 1) a confirmed or probable human case is identified or 2) a bird with confirmed or probable avian chlamydiosis was either:

- procured from a pet store, breeder, or dealer within 60 days of the onset of signs of illness,
- linked to a person with clinically compatible illness, or
- associated with several other suspect avian cases from the same source.

Other situations can be investigated at the discretion of the appropriate local or state public health department or animal health authorities.

Investigations involving recently purchased birds should include a visit to the site where the infected bird is located and identification of the location where the bird was originally procured (eg, pet shop, dealer, breeder, quarantine station). Authorities should document the number and types of birds involved, the health status of potentially exposed persons and birds, locations of facilities where birds were housed, relevant ventilation-related factors, and any treatment protocol. Contact information for the veterinarian associated with the establishment should be obtained. Recommendations in regard to isolation, testing, and treatment should be done in cooperation with an experienced avian veterinarian. Examination of sales records for follow-up of other birds that had contact with the infected bird may be considered.

Quarantine of birds

Depending on the state or locality's regulatory authority, animal health or public health officials might issue a quarantine order for all infected and exposed birds on premises where *C psittaci* infection has been identified. Ideally, decisions about quarantine should be made in consultation with state public health authorities, state animal health authorities, and an experienced avian veterinarian.[104,121] Public health and animal health authorities should inquire about any psittacosis protocols owners and operators may have, to assess how these may affect decisions regarding quarantine and movement of animals. The purpose of imposing a quarantine of birds within that facility is to prevent further pathogen transmission. Reasonable options should be made available to the owners and operators of pet stores. Preferably, the owner of quarantined birds should treat the birds in a separate quarantine area, which may or may not be on the same premises, to prevent exposure to the public and other birds. The quarantine area (cage or room) should be designed in accordance with the guidelines for environmental infection control in healthcare facilities when possible.[124,125] If the birds are transported to an off-site location for treatment, a dedicated vehicle specifically designed for the transportation of birds should be used. With the approval of state and local authorities, the owner can sell the birds after at least 7 days of treatment, provided that the new owner agrees in writing to continue the quarantine and treatment and is informed of the potential human health risk. After completion of the treatment or removal of the birds, a thorough cleaning and disinfection of the facility, and environmental testing for *C psittaci*, the quarantine can be lifted, and the facility can be restocked with birds. PCR-based environmental testing can be valuable in evaluating the effectiveness of cleaning and disinfection.

Bird importation regulations

Large-scale commercial importations of psittacine birds from foreign countries are not as prevalent as they were before 1993 when the Wild Bird Conservation Act was implemented.[126] Birds are imported as pets (ie, a member of a family) and also as avicultural specimens. Illegally imported (smuggled) birds are a potential source of *C psittaci* infection to domestic birds and people.

The US Department of Agriculture Animal Plant Health and Inspection Service, Veterinary Services, still regulates the legal importation of pet birds to ensure that exotic poultry diseases are not introduced into the United States. These regulations are set forth in the Code of Federal Regulations, Title 9, Chapter 1, Subpart A, 93.100.[127] Current import requirements do not include testing for *C psittaci*.

Appendix 1

Testing methods for *C psittaci* in birds

Bacteria are classified as *C psittaci* on the basis of shared biochemical characteristics and genome composition. The individual chlamydial organisms that meet these classification criteria are not identical and represent life forms that have evolved, and continue to evolve, through infection of both ancient and naïve hosts. Diversity in the organism, the level of exposure, and the host response may cause spurious test results in some individual animals.

Diagnosis of avian chlamydiosis can be difficult, especially in the absence of clinical signs. A single testing method might not be adequate. Therefore, use of a combination of culture, PCR-based detection, and antibody detection is recommended, particularly when only 1 bird is tested. Although there is no epidemiologic evidence of increased disease risk to young, elderly, or immunocompromised humans, more rigorous testing should be considered for birds in contact with these individuals. Consultation with an experienced avian veterinarian may help when selecting tests and interpreting results. Because proper sample collection techniques and handling are critical to obtain accurate test results, clinical laboratories should be contacted for specifics on specimen submission.

Pathologic diagnosis

In birds with avian chlamydiosis, cloudy air sacs and enlargement of the liver and spleen may be observed, but no specific gross lesion is pathognomonic. Chromatic or immunologic staining of tissue or impression smears can be used to identify suspect intracellular organisms in postmortem and biopsy specimens. Because of cross-reactivity of chromatic stains and commercial antibodies used for immunologic staining with non-chlamydial organisms, in situ hybridization, chlamydial isolation, or electron microscopy is required to confirm a diagnosis.

Bacteriologic culture

Use of culture is recommended to avoid limitations associated with other tests. Tissue specimens from the liver and spleen are the preferred postmortem specimens for culture. In live birds with suggestive clinical signs of chlamydiosis, a combined conjunctival, choanal, and cloacal swab specimen or liver biopsy specimen is recommended for testing. Swabs of conjunctival and choanal tissues may be most sensitive for detecting nucleic acid in subclinically infected birds. Depending on the stage of infection and affected tissue, infected birds might not shed detectable levels of *C psittaci* in feces.[103] If feces are chosen as a site for attempted detection of *C psittaci* from a single bird, serial fecal specimens should be collected for 3–5 consecutive days and pooled for submission as a single culture.

Chlamydia species are obligate intracellular bacteria that must be isolated in tissue culture or embryonated chicken eggs. Specialized laboratory facilities and training are necessary for reliable identification of chlamydial isolates and adequate protection of microbiologists. The diagnostic laboratory should be contacted for specific procedures required for collection and submission of specimens. The proper handling of specimens is critical for maintaining the viability of organisms for culture, and a special transport medium is required. Following collection, specimens should be refrigerated and sent to the laboratory packed in ice but not frozen.

Tests for antibodies

A positive serologic test result is evidence that the bird was infected by Chlamydiaceae at some point, but it might not indicate that the bird has an active infection. False negative results can occur in birds that have acute infection when specimens are collected before seroconversion. Treatment with an antimicrobial agent can diminish the antibody response. However, IgG titers may persist after successful treatment.

When specimens are obtained from a single bird, serologic testing is most useful when signs of disease and the history of the flock or aviary are considered and serologic results are compared with white blood cell counts and serum liver enzymes. A fourfold or greater increase in the titer of paired samples or a combination of a titer and antigen identification is needed to confirm a diagnosis of avian chlamydiosis.

Elementary body agglutination: The elementary body is the infectious form of *C psittaci*. Elemen-

tary body agglutination is commercially available. Based on immunoglobulin kinetics, the elementary body agglutination assay favors the detection of immunoglobulin M antibodies, which are generated and reach the highest titers early in an infection. Titers of 10 or greater are considered positive. However, increased titers can persist after treatment is completed.

Indirect fluorescent antibody test: Polyclonal secondary antibody is used to detect host antibodies (primarily IgG). Sensitivity and specificity varies with the immunoreactivity of the polyclonal antibody to various avian species. Low titers may occur because of nonspecific reactivity.

Complement fixation: Direct CF is more sensitive than agglutination methods. False negative results are possible in specimens from parakeets, young African grey parrots, and lovebirds. High titers can persist after treatment and complicate interpretation of subsequent tests. Modified direct CF is more sensitive than direct CF.

Tests for antigen

Tests for antigen detect the organism. These tests give rapid results and do not require live, viable organisms; however, false positive results from cross-reacting antigens can occur. False negative results can occur if there is insufficient antigen or if shedding is intermittent. As with all non–culture tests, results must be evaluated in conjunction with clinical findings.

Enzyme-linked immunosorbent assay: These tests may still be available but are not recommended.

Fluorescent antibody test: Monoclonal or polyclonal antibodies, fluorescein staining techniques, and fluorescent microscopy are used to identify the organism in impression smears or other specimens. These tests have similar advantages and disadvantages compared with enzyme-linked immunosorbent assay. This test is used by some state diagnostic laboratories. The commercial antibodies used for fluorescent antibody staining cross-react with non-chlamydial epitopes and are not diagnostic.

Tests for DNA: Numerous laboratories offer diagnostic testing using PCR. PCR amplification can be sensitive and specific for detection of target DNA sequences in collected specimens (eg, combined conjunctival, choanal, and cloacal swab specimens and blood). Results differ between laboratories because there are no standardized PCR primers and laboratory techniques and sample handling may vary. Because of the sensitivity of the assay, samples for PCR must be collected using techniques to avoid contamination from the environment or other birds. PCR does not differentiate between viable and nonviable microorganisms. Test results must be interpreted in light of clinical presentation and other laboratory tests. Some PCR-based assays do not distinguish between *C psittaci* and closely related chlamydial organisms, and diagnosticians should choose assays that specifically distinguish *C psittaci* DNA from other chlamydial organisms or interpret the positive DNA results with caution.

In situ hybridization: Use of chlamydial DNA probes is the preferred method for documenting the presence of chlamydial organisms in fixed tissues. Specific PCR-based detection methods have been developed for detecting chlamydial DNA in formalin-fixed tissue sections (C. R. Gregory et al, unpublished data, June 2016).

Additional tests

Genotyping: Genetic variation within *Chlamydia* species can affect host specificity, pathogenicity, and clinical signs. For example, variations in only 10 of ~900 genes control whether the human pathogen *C trachomatis* is likely to cause ocular, respiratory, or venereal disease.[128] Complete genome sequencing of *C psittaci* isolates have demonstrated that there is a similar percentage of difference in genotype A (predominately a psittacine bird isolate) and genotype B (an isolate predominate in Columbiformes) as there is between genotype A and genotype E (the index organism known to infect psittacine birds and humans).[129] It is probable that the genetic variations in the various genotypes of *C psittaci* alter host-bird interactions, as well as pathogen-human interactions, and genotyping of bird samples that are positive by PCR is recommended, particularly in cases involving multibird facilities or where human infections are suspected.

Additional diagnostic techniques are in use or under development. Readers are encouraged to research peer-reviewed reports on such tests before use.

Screening protocols using diagnostic tests

Until there is an effective vaccine to prevent avian chlamydiosis, retailers, bird producers, and veterinarians can help reduce the spread of this pathogen through pre- and post-purchase PCR-based testing using validated assays that distinguish *C psittaci* from other related chlamydias found in the pet industry. As a best practice, retailers should individually test cockatiels, love-

Table 3. Laboratories that test avian specimens for Chlamydiaceae.

Laboratory	Tests performed	Telephone number/web site
Diagnostic Center for Population and Animal Health, Michigan State University, East Lansing, MI, USA[a]	PCR	(517) 353-1683 http://www.dcpah.msu.edu
Comparative Pathology Laboratory, University of Miami, Miami, FL, USA[a]	EBA, IFA, EPH, DNA probe	800-596-7390 http://cpl.med.miami.edu/avian-and-wildlife/
IDL, University of Georgia College of Veterinary Medicine, Athens, GA, USA[a]	Culture, PCR, EBA, ISH, IHC, PCR of formalin fixed tissues, genotyping	(706) 542-8092 http://www.vet.uga.edu/idl
TVMDL, College Station, TX, USA[a]	PCR, DCF	(979) 845-3414 http://tvmdl.tamu.edu/
Diagnostic Virology Lab, NVSL, VS, APHIS, USDA, Ames, IA, USA[ab]	Culture, CF, other tests may be available upon request	(515) 337-7551 http://www.aphis.usda.gov/wps/portal/aphis/home/ (choose "Animal Health" and then "Laboratory Information Services" to access the NVSL site)

Abbreviations: APHIS, indicates Animal and Plant Health Inspection Service; CF, complement fixation; DCF, direct compliment fixation; EBA, elementary-body agglutination; EPH, plasma protein electrophoresis; IDL, Infectious Diseases Laboratory; IFA, indirect fluorescent antibody; IHC, immunohistochemistry; ISH, in situ hybridization; NVSL, National Veterinary Services Laboratories; PCR, polymerase chain reaction assay; TVMDL, Texas Veterinary Medical Diagnostic Laboratory; USDA, US Department of Agriculture; VS, Veterinary Services.

[a] NVSL is a USDA reference laboratory, and veterinarians are encouraged to contact their state veterinary diagnostic laboratories before submitting samples directly to NVSL.

[b] During December 2015–May 2016, an internet search was performed, and individual laboratories were contacted to obtain information regarding the availability of the diagnostic tests.

birds, and larger psittacine birds using a PCR-based assay on a combined swab collected from the conjunctiva, choana, and cloaca (feces) during a presale quarantine period. It has been shown experimentally that conjunctiva sampling is most sensitive for detecting chronically infected cockatiels that typically have minimal clinical signs of infection (T. N. Tully et al, unpublished data, 2007–2015). As a best practice for budgerigar testing only, before release from a presale quarantine, 17 years of epizootiologic data (B. W. Ritchie et al, unpublished data, May 2015) has shown that budgerigars from closed breeding flocks can be effectively tested for *C psittaci* DNA by housing them in groups of 20–25 birds and waiting 12–24 hours to collect a composite swab from the group. The swab should be used to sample the enclosure floor, perches, rims of water and food bowls, and feces. Pooled environmental testing has not been proven effective for other psittacine species.

Pet owners should seek companion birds from sources that use the best practices described above.

Laboratories that test avian specimens for C psittaci

Table 3 lists government and university laboratories that perform chlamydial diagnostic tests. There are numerous private laboratories that provide similar services. Inclusion in Table 3 does not imply endorsement by the National Association of State Public Health Veterinarians or constituent institutions.

Appendix 2

Treatment options for birds with avian chlamydiosis

Routine prophylactic antibiotic treatment is highly discouraged as it may cause adverse effects and could generate resistant strains of *C psittaci* and other bacteria. Although antibiotic-resistant *C psittaci* has not yet been reported in birds, resistant *Chlamydia suis* has been documented in swine.[130] Therefore, potential development of resistant strains of *C psittaci* is a concern for avian patients.

Treatment of avian chlamydiosis can be challenging, and treatment is extra-label. In the United States, use of all drugs should comply with the Food and Drug Administration regulations. Adverse effects may be encountered with any of the listed treatment methods. Although treatment protocols are usually successful, knowledge is evolving, and no single protocol ensures safe treatment or complete elimination of infection in

every bird. Therefore, treatment for avian chlamydiosis should be supervised by a licensed veterinarian after consultation with an experienced avian veterinarian.

Treating and caring for infected and exposed psittacine birds

General recommendations include:

- Isolate birds that are to be treated in clean and uncrowded cages.
- Protect birds from undue stress (eg, chilling, unnecessary relocation), poor husbandry, and malnutrition. These problems reduce the effectiveness of treatment and promote the development of secondary infections with other bacteria or yeast.
- Sick birds may consume inadequate amounts of medicated food or water, so they should initially be treated with medication delivered directly by mouth or injection.
- The effective treatment period for avian chlamydiosis has not been scientifically established. Ultimate clearance of the organism likely depends on the host immune system as well as the effects of antimicrobial treatment. Historically, a treatment period of 45 days has been recommended, except in budgerigars, where 30 days of treatment can be effective. Recent studies have shown that shorter treatment periods of 21–30 days may also be effective.[103] If shorter treatment periods are used, the birds should be retested using a PCR-based method 2–4 weeks after treatment.
- Continue medication for the full treatment period to avoid incomplete resolution of the infection.
  - Birds may have reduced chlamydial shedding within days of treatment initiation.
- Observe the birds daily and weigh them every 3–7 days. If the birds are not maintaining weight, have them reevaluated by a veterinarian.
- Remove all calcium and mineral supplements such as oyster shell, mineral blocks, and cuttlebone during treatment. High dietary concentrations of calcium and other minerals inhibit the absorption of tetracyclines. In hand-fed neonates where dietary calcium is required, the calcium and tetracycline should be given at least 4–6 hours apart.
- Good husbandry practices should be followed to prevent opportunistic infections.
  - Clean up all spilled food promptly.
  - Wash food and water containers daily.
  - Provide appropriate vitamins daily.
- Treated birds can be reinfected; therefore, contaminated aviaries should have a final thorough cleaning and disinfection several days before treatment ends.
- Posttreatment testing using a PCR-based method should be conducted no sooner than 2 weeks after treatment is completed.
- Caretakers should be provided with simple, concise written treatment procedures to ensure treatment success and with information about preventing further transmission.

Treatment using doxycycline in psittacine birds

Doxycycline is presently the drug of choice to treat birds with avian chlamydiosis. It is better absorbed and more slowly eliminated than other tetracyclines, thus allowing lower drug doses (improving palatability with food or water-based administration) or less frequent administration (improving ease of treatment). Treated birds should be monitored for signs of doxycycline toxicosis to include:

- general signs of illness (eg, signs of depression, inactivity, decreased appetite),
- green- or yellow-stained urine, or
- altered results of hepatic tests (high serum activities of aspartate aminotransferase and lactate dehydrogenase and high serum concentration of bile acids). If toxicosis occurs, administration of doxycycline should be stopped and supportive care provided until the bird recovers. Treatment with a different regimen or lower doxycycline dose can be tried after the bird no longer shows signs of toxicosis. The following are several options for treatment. Options should not be combined in the same day.

Doxycycline-medicated feed for budgerigars and cockatiels: It is critical to use the recommended doxycycline formulation and dietary ingredients to achieve safe and effective results. Based on use in practice and research, budgerigars and cockatiels can be treated with the following medicated diet.[131,132]

1. Mix 1 part cracked steel-cut oats with 3 parts hulled millet seed (measured by volume).
2. To each kilogram (kg) of oat-millet mixture, add 5–6 mL of sunflower oil. Mix thoroughly to coat all seeds.
3. Add 300 mg of doxycycline hyclate (from capsules) per kilogram of oat-millet-oil mixture, and mix thoroughly to ensure that oats and millet seeds are evenly coated.

Table 4. Sources of medication for treatment of avian chlamydiosis.

Contact	Product	Telephone number/web site
Doxycycline		
Local pharmacies	1. Doxycycline hyclate tablets 15, 75, 100, 50, and 150 mg 2. Doxycycline calcium oral suspension 3. Doxycycline monohydrate oral suspension	
Dr Gerry M Dorrestein, Wilhelminalaan 19A, 5512BJ Vessem, The Netherlands	Vibramycin SF IV, 20 mg/mL, 5-mL ampule[a]	Tel: 000 316 11057602 Fax: 000 314 97591677 dorresteingm@planet.nl
Medicated Feed		
Avi-Sci Inc, St. Johns, MI, USA	Chlortetracycline (CTC) medicated diet (1%)	Tel: 800.942.3438 mike@avi-sci.com
Zeigler Brothers Inc, Gardners, PA, USA	CTC, 1% (special order, 50 lb minimum)	Tel: 800.841.6800 www.zeiglerfeed.com

[a] Importation must be in accordance with FDA Regulatory Procedures Manual.[134] For questions or clarification, contact the Food and Drug Administration, Center for Veterinary Medicine, Division of Compliance at (240) 276-9200.

Prepare fresh medicated oat-millet-oil mixture daily, because doxycycline stability in this diet is unknown. Feed as the sole diet. The oats and hulled millet seed are available at health food stores. Small-sized millet should be selected. Sunflower oil is available in grocery stores. Doxycycline hyclate capsules are available in 50- and 100-mg sizes.

Doxycycline-medicated water: Results of pharmacologic studies indicate that doses of 200–400 mg of doxycycline hyclate per liter of water for cockatiels, 400–600 mg/liter for Goffin's cockatoos, and 800 mg/L for African grey parrots will maintain therapeutic concentrations.[131,133] Research data are lacking for other species, but empiric use of 400 mg/L of water has been successful for many psittacine birds. Medicated water should be prepared daily and provided in clean bowls, rather than water bottles. Do not use medicated water for budgerigars as it will *not* maintain therapeutic concentrations.[132]

Orally administered doxycycline: Doxycycline is the drug of choice for oral administration; either the monohydrate or calcium-syrup formulations can be used. Dosage recommendations are as follows: 25–35 mg/kg every 24 hours for cockatiels; 25–50 mg/kg for Senegal parrots and blue-fronted and orange-winged Amazon parrots; and 25 mg/kg every 24 hours for African grey parrots, Goffin's cockatoos, blue and gold macaws, and green-winged macaws. Precise dosages cannot be extrapolated for other species; however, 25–30 mg/kg every 24 hours is the recommended starting dosage for cockatoos and macaws, and 25–50 mg/kg every 24 hours is recommended for other psittacine species. If the bird regurgitates or refuses the drug, another treatment method should be used.

Injectable doxycycline: The only suitable doxycycline formulation for intramuscular (IM) injection is Vibramycin SF IVa (Vibravenos, Pfizer, Rotterdam, The Netherlands), a specific European formulation that can be imported in small quantities into the United States (Table 4). It is effective if administered at doses of 75–100 mg/kg IM every 5–7 days for the first 4 weeks and subsequently every 5 days for the duration of treatment. This formulation can cause irritation at the injection site, but it is usually tolerated. Other injectable doxycycline hyclate formulations may cause severe tissue reactions if given intramuscularly and should not be used.

Alternative treatment regimens for psittacine birds

Azithromycin: Cockatiels treated with azithromycin at 40 mg/kg PO were free of infection after treatment for 21 days.[103] It is not known if this treatment regimen is effective in other species.

Injectable oxytetracycline: Limited information exists to guide the use of an injectable, long-acting oxytetracycline product LA-200 (Zoetis, Florham Park, NJ, USA). Current dosage recommendations are as follows: subcutaneous (SC) injection of 75 mg/kg every 3 days in Goffin's cockatoos, blue-fronted and orange-winged Amazon parrots, and blue and gold macaws.[135] This dosage might be suitable for other species but has not been tested. This product causes irritation at the site of injection and is best used to initiate treatment in ill birds or those that are reluctant to eat. After stabilization with oxytetracycline treatment and the birds are eating and drinking normally, the birds should receive another form of treatment to reduce the irritation that is caused by repeated oxytetracycline injection.

Chlortetracycline (CTC) medicated feed: Chlortetracycline medicated feed has historically been used for flock treatment; however, doxycycline regimens are preferred. If used, CTC medicated feed should be the *only* food provided to the birds during the entire treatment. Birds' acceptance of medicated feed is variable; thus, food consumption should be well monitored. Acceptance can be enhanced by first adapting the birds to a similar, nonmedicated diet. Treatment begins when the birds accept the medicated feed as the sole food in their diet. The following options are available:

- Medicated mash diets (ie, >1% CTC with <0.7% calcium) prepared with corn, rice, and hen's scratch.[136]
- Pellets and extruded products containing 1% CTC can be used. They are available and appropriate for use with pet birds. Select a pellet size appropriate for the size of bird being treated.[137,138]
- A special diet might be necessary for lories and lorikeets, which feed on nectar and fruit in the wild.[139]

Treatment methods not recommended for psittacine birds

Use of water medicated with chlortetracycline (Aureomycin), oxytetracycline (Terramycin), or other tetracycline products (except doxycycline) is not recommended. These products may reduce water consumption, are not likely to be effective, and may interfere with subsequent disease testing.

Treatment in other avian species

Limited studies and clinical experience indicate that the treatment methods described for use in psittacine birds may be effective in other avian species, including doxycycline-medicated water in doves and a novel doxycycline formulation in drinking water for pigeons.[140,141] However, variability in drug metabolism and adverse drug effects make it impossible to make uniform recommendations for treatment.[142,143] An avian or zoological veterinarian experienced with care of the target species should be consulted to obtain treatment recommendations. Posttreatment testing is recommended.

Sources of medication

The sources in Table 4 are not listed as an endorsement of the companies or products. Other sources might be available. Use of any compounded medication should be in compliance with current Food and Drug Administration and state regulations.[144]

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