Avian Ophthalmology Part 1: Anatomy, Examination, and Diagnostic Techniques

A. Michelle Willis, DVM, and David A. Wilkie, DVM, MS
Department of Veterinary Clinical Sciences
The Ohio State University
601 Vernon L. Tharp Street
Columbus, Ohio 43210, USA.

Presented by Roberto Aguilar

Introduction

This report presents an overview of basic avian ocular anatomy is provided, and the steps involved in performing a complete ophthalmic examination of a bird are reviewed. Additionally, a general review of ophthalmic diagnostic techniques is discussed.

The specialty of avian medicine continues to evolve, and with that evolution comes an increased interest in the variety of organ-specific subspecialties involved in the medical management of companion birds and aviary species. The purpose of this article is 1) to review basic anatomy of the avian eye, 2) to discuss ophthalmic examination and diagnostic procedures, and 3) to provide a general overview of the more common ophthalmic conditions affecting companion birds, with an emphasis on psittacine species. The first two sections will be discussed in Part 1, and ophthalmic diseases will be reviewed in Part 2.

Anatomy of the Avian Eye

Adnexa

Avian eyelids are thin and sometimes transparent, with the lower lid usually containing a fibroelastic tarsal plate. [1] Meibomian glands are absent.[2] The conjunctiva is morphologically similar to that of mammals. Although not documented in companion avian species, a conjunctiva-associated lymphoid tissue has been characterized in poultry; this tissue is probably associated with local immunity.[3, 4] The nictitating membrane is well developed and actively mobile. In most avian species, this structure is drawn from the dorsonasal aspect of the eye over the cornea, and it is moved by the contracture of the pyramidalis muscle, which originates from the posterior sclera.[5] The tendon of the pyramidalis muscle loops over the optic nerve through a sling formed by the quadratus muscle. Both muscles are innervated by cranial nerve VI.[6] There is no gland of the nictitating membrane proper; however, a lacrimal gland is present inferotemporal to the globe, and a harderian gland sits adjacent to the posterior sclera, near the base of the nictitans but not as a part of it. The oblique and rectus extraocular muscles are thin and poorly developed, and no true retrobulbar muscle group is present. Head movements generally compensate for the reduced mobility of the globe. Two lacrimal puncta drain secretions into a nasolacrimal duct and into the nasal cavity.

The avian orbit is typically large and incomplete.[5-7] The paranasal sinuses of the avian skull (particularly the infraorbital sinus) are commonly involved in upper respiratory diseases and, because of their close proximity to the orbit, can become involved in secondary orbital and ocular disease.[8]

Globe

Three basic avian globe shapes exist: flat, tubular, and globular. The shape is dictated by the presence of cartilage within the posterior sclera and the scleral ossicles, which lie caudal to the limbus as a series of imbricating membranous bones.[5] In psittacine and passerine birds, which normally have narrow skulls, the typical globe shape is flat, with a short anterior-posterior length and a relatively large hemispherical posterior segment.

Anterior segment

The avian cornea is thinner than that of mammals and has a Bowman's layer (anterior limiting membrane consisting of a thin layer of condensed stroma) beneath the epithelium, similar to that of the human cornea.[5] The iris contains lipochrome pigments, which vary in color in birds of different species, age, and sex. The iris musculature of birds is composed mainly of striated muscle fibers, with varying amounts of nonstriated fibers.[9] The striated muscle allows for pupil function to be partly under voluntary control.[5] The crystalline lens is surrounded by a capsule that contains a metabolically active epithelium in its anterior portion.[10] The equatorial region contains an annular pad that is not optically active but may serve a nutritive function. The cortex and nucleus comprise the bulk of the tissue. In birds, the process of accommodation has much interspecific variation and involves a combination of changes in comeal curvature and anterior movement and deformation of the lens.[10]

Posterior segment

The avian vitreous is comparable to that of mammals. The anatomy of the avian ocular fundus, however, is unique in several ways. The retina is atapetal and avascular, nourished primarily by the underlying choroid. The pecten, a heavily pigmented and highly vascularized fanlike structure, projects into the vitreous from the optic nerve head.[11] This structure has many proposed functions; most researchers believe that it functions for ancillary retinal nutrition.[12] Rod and cone photoreceptors are present in the avian retina, with cones containing oil droplets. Although their exact function is unknown, these droplets are thought to filter the light entering cones.[13] An area centralis (region of high cone density) is usually present, but the presence and number of fovea (a retinal "pit" where the inner retinal layers are spread aside to allow direct light stimulation of the cones) is species-dependent.[5] As noted above, the optic nerve head is situated beneath the pecten, which obscures its view ophthalmoscopically. In avian species, there is 100% decussation of the optic nerves.

Ocular Examination and Diagnostic Techniques History and physical examination

Recording an accurate history regarding the duration and characteristics of the bird's ocular problem is essential. Pay special attention to appetite, diet, and husbandry practices, and document recent transport or exposure to other birds, previous illnesses, and any concurrent signs of systemic disease (character and color of feces and urates; feather, beak, and skin quality; pruritus; behavioral changes). Because many common clinical signs of primary ophthalmic disease (conjunctival hyperemia, ocular discharge, anterior uveitis, exophthalmia) may accompany infectious or

noninfectious systemic diseases, one should always examine the eye with attention to general physical status. For this reason, hematologic testing and plasma biochemical analysis are standard components of the data base for birds with ophthalmic disease.

In general, ophthalmic examination techniques used in other animals, such as fluorescein staining, cytologic examination, bacterial and fungal culture, and tonometry, can be performed on birds, with the limiting factor in some cases being the size of the eye. For consistency and accuracy, develop a systematic method for ocular examination that is the same for all species. Before focal examination is done, assess the general appearance of the head and the periocular region. Evaluate ocular position, mobility and symmetry of the globe, and size and symmetry of the pupils. Observe the character of the periocular feathers and note any ocular discharges, including discharge from the nares, that may indicate concurrent upper respiratory tract involvement.

Assessing vision and cranial nerve fuction

In birds, vision can be a challenge to assess. Most birds exhibit avoidance behavior or excursion of the nictitans rather than the menace response, which is readily demonstrated in most mammalian companion animals. Unilateral vision loss is sometimes associated with an abnormal head posture or head tilt.[14] Some birds will fixate on a brightly colored object and follow its motion. Eyelid mobility and function can be confirmed by gently tapping the lateral or medial periocular region. This can be performed with a finger tap or, alternatively, with a cotton-tipped swab. A cotton-tipped swab can also be used to assess comeal sensation: a strand of cotton teased from the tip can be used to tickle the cornea of the bird when the bird is approached from the side of the face (so that vision is not stimulated). Birds lack muscles of facial expression;[15] the obicularis oculi muscle is reportedly innervated by the mandibular branch of cranial nerve V.[16]

The pupillary light reflex can be elicited in birds, but its interpretation is complicated by the fact that voluntary constriction and dilation of the pupil is possible, even without direct retinal stimulation. Because the optic nerves decussate completely, a neuronal consensual light reflex is not anticipated.[17]

The apparent response observed in the contralateral eye has been attributed to indirect stimulation of the contralateral retina through the thin orbital bone. However, this theory has recently been challenged by the observation that 13 of 18 chickens with experimental unilateral transection of the optic nerve exhibited no direct response in the operated eye but did exhibit an indirect response. The nonoperated eyes showed direct but no indirect responses.[18]

Close examination of the avian eye requires gentle restraint, a bright focal light source, and ideally some method of magnification. A bird can be restrained by wrapping a light towel under the neck and around the wings; the handler can hold the head at the base of the skull for more stability of the head. If general restraint induces considerable stress, inhalation anesthesia may be needed to facilitate examination.

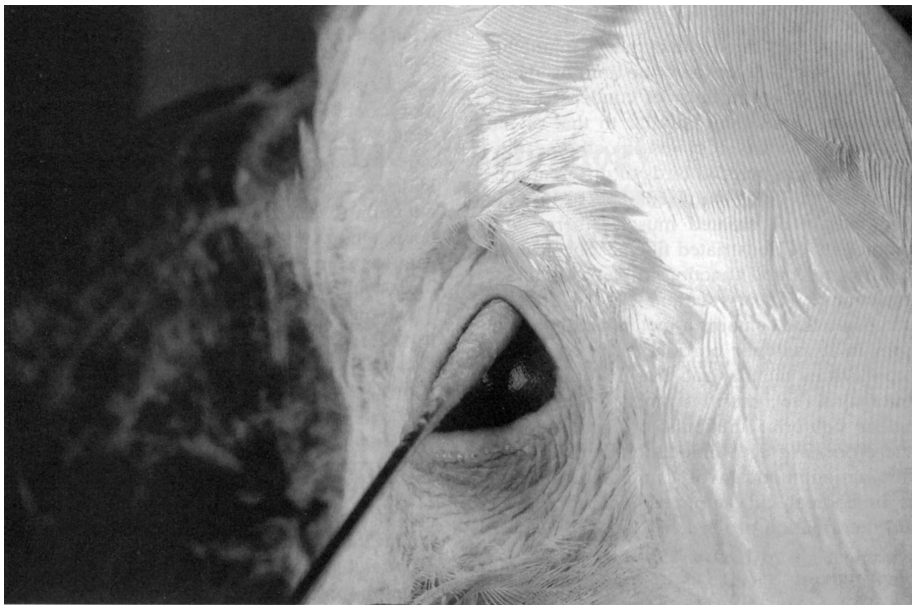

Figure 1. Sampling the dorsal conjunctival fomix of a cockatoo for bacterial culture. The use of a small calcium alginate or rayon swab allows the avoidance of contact with the eyelid and periocular facial skin and feathers.

Assessing tear production

Williams reports Schirmer tear test results of 8 ± 1.5 mm (mean ± SD) in large Psittaciformes such as African grey parrots *(Psittacus erithacus)* and 4 ± 1 mm in small species such as lories and conures (the standard 6-mm-wide strips are trimmed to 4 mm for easier insertion into the small conjunctival cul-de-sac).[8] Tear production also can be estimated by the phenol red thread tear test, which has recently been assessed in dogs.[19] Although this test has not been critically evaluated in birds, the shorter time required to complete the test and the fine gauge of the thread used may make this an appropriate method for comparing the results of birds of the same species. Always perform tear tests before instilling any fluids on the ocular surface.

Culture

Samples for culture and sensitivity testing should also be collected before instilling a topical anesthetic. The less mobile upper eyelid conjunctiva is recommended for ease of sampling (Figure 1); corneal samples should be acquired from the center and edge of the affected region. Small rayon or calcium alginate culturette tips (ie. Mini-tip, Becton Dickenson Microbiology Systems, Cockeysville, MD, USA, or Calgiswab, Spectrum Laboratories, Dallas, TX, USA) are more compatible with the small anatomy of the avian eye and are less likely than the larger variety to become contaminated from inadvertent sampling of the eyelid margin or facial skin. Swab samples can be plated immediately on appropriate media for bacterial or fungal culture. If a delay is necessary before the sample is processed, ensure that the sample is kept moist in transport media. Attempts to isolate *Chlamydia* or *Mycoplasma* species may require more stringent handling and growth requirements. Before collecting samples, contact the particular diagnostic laboratory for specific recommendations on sample submissions.

A survey of the conjunctival flora in the eyes of 117 clinically normal captive exotic birds (5 orders) identified bacterial isolates in 83% and fungal isolates in 14%.[20] In psittacines birds,

Staphylococcus or *Corynebacterium* species were the predominant species identified, whereas in nonpsittacine birds, a mixed bacterial population was more common. Gram-negative organisms were more often isolated from Struthioniformes and Anseriformes; this fact may be related to the feeding habits and environment of birds in these orders. *Mycoplasma* species were not recovered, but the authors commented that the method of recovery used may have been inadequate. Cytologic examination of conjunctival cells of selected birds did not reveal chlamydial inclusions; however, the number of birds examined was not indicated.

Examining the anterior segment

With magnification (ie, a head loop or a magnifying lens) and a bright light source (ie, a Finhoff transilluminator, an otoscope head, or, ideally, a slit lamp or the slit beam of a direct ophthalmoscope), the anterior segment of the eye can be examined. The lower eyelid is typically more mobile than the upper eyelid. The nictitating membrane is very mobile and is responsible for spreading the tear film across the cornea. The nictitating membrane is clear to moderately opaque, depending on the species, and moves rapidly across the cornea. Foreign bodies may become trapped under the nictitans, producing considerable irritation and inflammation. The leading edge of the nictitans can be grasped with an atraumatic forcep (ie, a Graefe forcep) to extend it for examination. The cornea should be clear and moist. The sclera is not readily observed in most birds because of the tight fit of the eyelids at the limbus. Focusing a slit beam of light on the cornea and observing any scatter of light in the anterior chamber can be used to assess the chamber clarity. The iris appearance varies among species but should have a smooth, uniform texture. The iris vasculature is extends but may be variably obscured by pigment.[5] The anterior surface of the lens is almost planar in psittacine birds; it should be smooth and optically clear.

The pupils of birds cannot be reliably dilated with autonomic drugs; however, there appear to be species differences as well as sensitivities to apparent systemic absorption of these substances.[9] In one study of cockatoos *(Cacatua* species), African grey parrots, and blue-fronted Amazon parrots *(Amazona aestiva),* several topically applied autonomic and curariform drugs were evaluated with and without surface-acting agents.[9] Vecuronium (1 drop followed by 1 drop 2 minutes later of an 0.8 mg/ml solution in 0.9% NaCI) without a surface-acting penetrating agent administered in one eye produced the most consistent and greatest pupillary dilation in all three species, with the fewest side effects.[9] When a surface-acting agent (1% saponin) was added to the vecuronium, one cockatoo collapsed and died before neostigmine could be administered. This result was attributed to the increased systemic absorption of vecuronium afforded by the surface-acting agent, as the same bird did not develop systemic side effects when given the same dose of vecuronium without saponin. Monitoring respiration rate and depth of inspiratory excursion is recommended, and an anticholinesterase drug (ie, neostigmine) should be available for immediate intravenous delivery if complications occur. Often, the pupil can be sufficiently dilated by simply darkening the room and using a low level of illumination to examine the fundus.[14]

Examining the posterior segment

The vitreous body should be clear and formed. Opaque vitreal strands, asteroid hyalosis, and syneresis (liquefaction of the vitreous) may indicate prior intraocular inflammation. The avian retina is typically gray, with variable degrees of pigment and a reddish hue associated with the underlying choroid. The accordion-like, heavily pigmented pecten sits over the optic nerve head, obscuring its view. The posterior segment can be examined by direct or indirect

ophthalmoscopy. The best results are achieved by indirect ophthalmoscopy with a focal light source and a condensing lens (a 28D, 30D, 40D, 60D, or 90D may be useful, depending on the size of the eye).

Evaluating intraocular pressure

The use of the Schiotz tonometer is suitable only for large birds, and even then the instrument can be cumbersome for the examiner and stressful for the bird. The Tonopen (Tonopen-XL, Mentor O&O, Norwell, MA, USA), an applanation tonometer, has been shown to provide reproducible readings on eyes with a minimal corneal diameter of 9 mm (eg, an Amazon parrot eye)[21] (Figure 2). With corneal diameters from 5 mm (eg, a cockatiel eye) to 9 nun, measurement reproducibility becomes limited, and with corneal diameter below 5 mm (eg, a budgerigar eye), readings are not reliable. In a series of tonometric examinations of 275 birds with healthy eyes, physiologic values of intraocular pressure, measured with the Tonopen, were between 9.2 and 16.3 mm Hg. Topical anesthetics should be applied to the corneal surface 10 to 15 seconds before measuring intraocular pressures. Alternatively, the intraocular pressure can be estimated by gently pressing a moist cotton swab onto the anesthetized cornea.[14] In a normal eye, the cornea will indent only slightly (1—2 mm) and symmetrically with the fellow eye, whereas with hypotony (associated with uveitis), the cornea will indent to a greater degree. Increased intraocular pressure can also be estimated with this method, and results can be supported with other ophthalmic indicators of glaucoma.

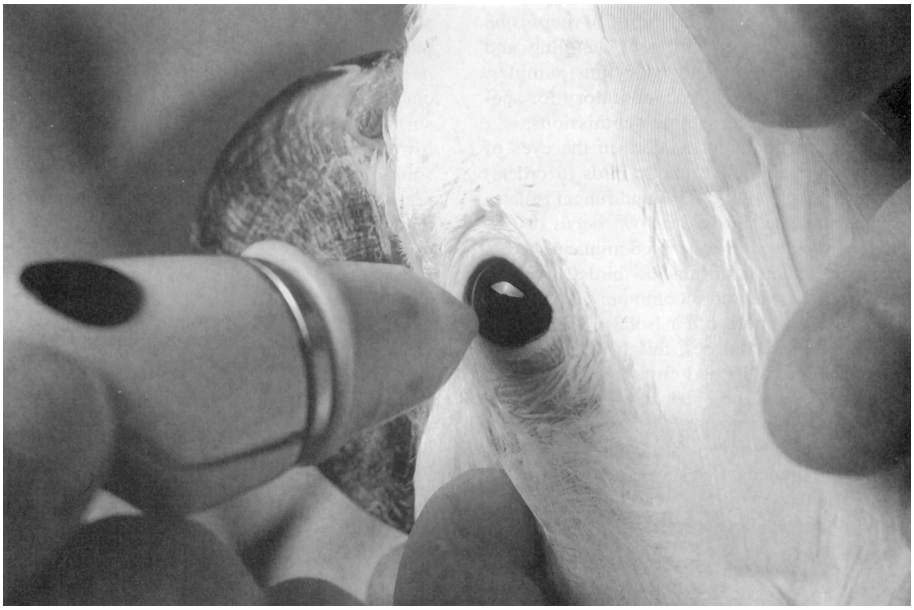

Figure 2. Intraocular pressure can be estimated reliably by using an applanation tonometer (Tonopen-XL, Mentor O&O, Norwell, MA, USA) in large birds (ie, those with corneal diameter of >9 mm) after administering a topical anesthetic.

Cytologic examination

Indications for cytologic examination include conjunctivitis and comeal ulcers that are accompanied by an inflammatory infiltrate. Additionally, perio.cular mass lesions, such as those involving the sinuses or eyelids, may be aspirated for examination. To obtain a conjunctival sample, the palpebral surface of the upper lid is easy to access. A drop of topical anesthetic

should be administered 15 to 20 seconds before sampling, and any excess can be wicked away with a cotton-tipped swab. Corneal or conjunctival cells can be gently debrided with a sterile Kimura (Storz, St. Louis, MO) platinum spatula. Alternatively, a small sterile brush can be used to exfoliate comeal or conjunctival cells.[22] Acquired cells are lightly spread across the focal region of a glass slide; cells are then fixed and stained for cytologic examination.

Imaging

The radiographic anatomy of the psittacine skull has been reviewed previously,[7, 23] and radiography is an appropriate means of evaluating the orbit and scleral ossicles for fractures and for bony or sinus involvement of suspect inflammatory or neoplastic lesions. Ocular ultrasound may be a helpful adjunct in examining an eye with advanced comeal or lens opacification or in delineating retrobulbar lesions.[24]

Electrodiagnostics

The electroretinogram, which assesses function of the retinal photoreceptors, has been evaluated in poultry and raptors[25, 26]; however, established reference values for psittacine birds have not been reported. As in mammals, the primary clinical indications for electroretinography are to rule out retinal photoreceptor degeneration as a cause for visual dysfunction and to assess retinal function before cataract surgery.

Practical considerations for avian ophthalmic surgery

General anesthesia is required for most surgical procedures involving the eye and ocular adnexa. Of particular concern is the risk of cardiac depression associated with manipulating the globe. The oculocardiac reflex has been reported recently with fatal sequelae in a cockatiel,[27] illustrating the importance of this phenomenon in avian species. The oculocardiac reflex manifests as a trigeminal-vagal reflex, with the afferent pathway extending by way of the ophthalmic branch of the trigeminal nerve to the Gasserian ganglion. The efferent route goes through the vagus nerve and ends in cardiac muscle, where it slows sinus rhythm and decreases conduction and contractility.[28] Should cardiac depression from this reflex occur, discontinue ocular manipulations, deliver positive pressure ventilation, and administer an anticholinergic agent intravenously.

Even a small face mask can impair access to the eye and periocular region during surgery; therefore, endotracheal intubation is advised. In birds, air sac perfusion anesthesia also may be a suitable alternative for ocular surgery. The primary advantages of this delivery route include free surgical access to the head for ocular procedures and stable or decreasing intraocular pressure.[29] Air sac perfusion anesthesia consists of a retrograde perfusion of the lung air sac system through a perfusion catheter in the left caudal thoracic air sac. Monitoring oxygenation by pulse oximetry is helpful, as air sac perfusion causes a reversible apnea because the reduced partial pressure of carbon dioxide removes the stimulation of the respiratory center.

Common surgical procedures include periocular mass removal, enucleation,[8-30] evisceration,[31,32] sinus irrigation,[33] and repair of lacerations involving the eyelids or nictitating membrane. The proper selection, care, and use of ophthalmic instruments is critical to the success of surgery, and this subject has recently been reviewed.[34] For optimal results, use magnification (X4-X10), manipulate tissues gently and precisely with instruments that are appropriately sized for the task, and use suture material (6-0 or smaller) that is suitable for the tissue undergoing repair. Basic

principles of surgery for the periocular region of birds are similar to those followed for larger animals; however, minimizing blood loss is paramount. The use of cotton-tipped applicators, absorbent cellulose sponge wedges (Weck-Cel, Xom-ed Surgical Products, Jacksonville, FL, USA), he-mostatic foam (Gelfoam, Upjohn, Kalamazoo, MI, USA), and a bipolar radiocautery can be helpful in eliminating excessive blood loss. A CO; surgical laser (Accuvet CO; surgical laser, Luxar-ESC Medical, Bothell, WA, USA) has been advocated for use in avian surgical procedures, including the excision or vaporization of eyelid masses.[35] The CO; surgical laser will cut while sealing off vessels, and the ability to adjust power and rate of laser energy delivery means that surrounding tissue damage is minimal. Five watts delivered with a 0.3-mm tip (for cutting out) or with an 0.8-mm ablation tip on a 40% pulsed mode (for vaporization) is recommended for eyelid masses. Adequate eye protection and lubrication are required during surgery.

References

1. Millichamp NJ. Exotic animal ophthalmology. *In:* Gelatt KN (ed). Veterinary ophthalmology. 2nd ed. Philadelphia: Lea and Pebiger, 1991:689-694.
2. Kem TJ. Exotic animal ophthalmology. *In:* Gelatt KN (ed). Veterinary ophthalmology. 3rd ed. Baltimore: Lippincott, Williams and Wilkins, 1999:1284-1293.
3. Fix AS, Arp LH. Morphologic characterization of conjunctiva associated lymphoid tissue in chickens. Am J Vet Res 1991;52:1852-1859.
4. Fix AS, Arp LH. Conjunctiva-associated lymphoid tissue (CALT) in normal and *Bordetella avium-in*-fected turkeys. Vet Pathol 1989;26:222-230.
5. Duke-Elder S. The eyes of birds. *In:* Duke-Elder S (ed). System of ophthalmology. V.I: The eye in evolution. St. Louis: CV Mosby, 1958:397-427.
6. Kem TJ, Paul-Murphy J, Murphy CJ, et al. Disorders of the third eyelid in birds: 17 cases. J Avian Med Surg 1996;10:12-18.
7. Murphy-Paul JR, Koblik PD, Stein G, Pennick DG. Psittacine skull radiography: anatomy, radiographic technic and patient application. Vet Radiol 1990;31:218-224.
8. Williams D. Ophthalmology. *In:* Ritchie BW, Ham-son GJ, Harrison LR (eds). Avian medicine: principles and application. Lake Worth, PL: Wingers, 1994: 673-694.
9. Ramer JC, Paul-Murphy J, Brunson D, Murphy CJ. Effects of mydriatic agents in cockatoos, African gray parrots, and blue-fronted Amazon parrots. J Am Vet Med Assoc 1996;208(2):227-230.
10. Brooks DE. Avian cataracts. Semin Avian Exotic Pet Med 1997;6:131-137.
11. Bellhom RW, Bellhom MS. The avian pecten. I. Huorescein permeability. Ophthalmic Res 1975;7:1-7.
12. Bellhom RW. Retinal nutritive systems. Semin Avian Exotic Pet Med 1997;6:108-118.
13. Bennett ATD, Cuthill 1C. Ultraviolet vision in birds: what is its function? Vision Res 1994;34:1471-1478.
14. Davidson M. Ocular consequences of trauma in raptors. Semin Avian Exotic Pet Med 1997;6:121-130.
15. King AS, McLelland J. Special sense organs. *In:* King AS, McLelland J (eds): Birds, their structure and function. Philadelphia: Bailliere Tindall, 1984: 284-314.
16. Jones MP, Orosz SE. Overview of avian neurology and neurologic diseases. Semin Avian Exotic Pet Med 1996;5:150-164.
17. Levine J. Consensual light response in birds. Science 1955;122:690.
18. Li T, Howland HC, et al. There is a true consensual pupillary light response in chickens. IOVS (Investig Ophthalmol Vis Sci) 1996;37:sl58.

19. Brown MH, Galland JC, Davidson HJ, Brightman AH. The phenol red thread tear test in dogs. Vet Comp Ophthalmol 1996;6:274-277.
20. Wolf ED, Amass K, Olsen J. Survey of the conjunc-tival flora in the eye of clinically normal, captive exotic birds. J Am Vet Med Assoc 1983;183:1232-1233.
21. Korbel R. Tonometry in avian ophthalmology. J Assoc Avian Vet 1993;7:44.
22. Willis M, Bonous DI, Hirsch S, et al. Conjunctival brush cytology: evaluation of a new cytological collection technique in dogs and cats with a comparison to conjunctival scraping. Vet Comp Ophthalmol 1997;7:74-81.
23. Kotska V, Kratwald-Junghams KE, Tellhelm B. Radiology of the avian skull. J Vet Med (Ser A) 1991; 38:175-186.
24. Romagnano A, Mashima TY, Bames HJ, et al. Pituitary adenoma in an Amazon parrot. J Avian Med Surg 1995;9(4):263-270.
25. Roze M. Comparative electroretinography in several species of raptors. Trans Am Coll Vet Ophthalmol 1990,21:45-48.
26. Korbel R, Stutz S. Fundamentals of electroretinography in the common buzzard *(Buteo buteo)*. Proc Eur Coll Avian Med Surg 1997;2:211-219.
27. Pipo RA, Broadstone RV, Murphy CJ. Lethal ocu-locardiac reflex in a cockatiel. Vet Comp Ophthalmol 1996;6(1):27-29.
28. Donlon JV. Anesthesia for eye, ear, nose and throat surgery. *In:* Miller RD (ed). Anesthesia. Vol. 2. New York: Churchill Livingstone, 1981:1272-1273.
29. Korbel **R,** Milovanovic A, Erhardt W, et al. The aero-saccular perfusion with isoflurane in birds—an anesthetical measure for surgery in the head region. Proc Second Conf Eur Assoc Avian Vet. Utrecht/NL 1993:9-42.
30. Murphy CJ, Brooks DE, Kern TJ, et al. Enucleation in birds of prey. J Am Vet Med Assoc 1983; 183: 1234-1237.
31. Karpinski LG. Ophthalmology. *In:* Harrison GJ, Har-rison LR (eds). Clinical avian medicine and surgery. Philadelphia: WB Saunders, 1986:278-281.
32. Neuman U, Kummerfield N. Implantation of an intraocular prosthesis in a gray parrot. Tierarztl Prax 1983;11:195-199.
33. Bennett RA, Harrison GJ. Soft tissue surgery. *In:* Rit-chie BW, Harrison GJ, Harrison LR (eds). Avian medicine: principles and application. Lake Worth, PL: Wingers, 1994:1106-1107.
34. Greven VL. Ophthalmic instrumentation. Vet Clin N Am Small Anim Pract 1997;27:963-986.
35. Parrott T. Using the CO; laser in avian practice. Proc Annu Conf Assoc Avian Vet 1998:21-23.