Avian Ophthalmology - Principles and Application

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SUMMARY

Certain avian specific capacities – like flying – are closely bound to fully functional vision underlining the importance of avian ophthalmology. In addition, ocular lesions in birds are an expression of systemic disorders more than in mammals and therefore represent an important diagnostic criterion. The ocular symptomatology frequently enables specific conclusions to be drawn on suspected disorders or it may even be pathognomonic for a certain disease. Thus, the avian eye may be seen – in a much larger extent than in mammals - as a ”diagnostic window“. On an average, more than 30 % of all traumatised birds (incidence higher in raptors than in pet birds) are suffering from ocular lesions, which are most often hidden within the inner structures of the eye with haemorrhages arising from the pectin oculi. Ophthalmoscopy, i. e. examination of the posterior eye segment, therefore is obligatory in traumatised birds. Regarding to these facts avian ophthalmology is not a highly specific working field within avian medicine but it should be an integral part of the general examination procedure. After a short review on anatomical and physiological peculiarities, commonly and newly developed routine ophthalmological examination procedures will be described followed by a description of clinical pictures in the eye of various patient groups based on an etiological schematization. It has to be pointed out, that avian ophthalmology is getting more and more important in terms of avian visual perception, which strikingly differs from that of man (including avian visual perception within the UV and the ability to resolve high frequence flicker rates). These aspects will be of great importance for animal welfare issues due to the fact, that commercially kept poultry are commonly kept under artificial light sources, which meet human visual perception requirements only but lack those of avian vision.

INTRODUCTION

In many birds the eye is the most important sensory organ. The capacities of the avian eye which exceed those of the mammalian eye in part are an adaptation to the specific way of life and habitats as well as physical activities that are closely bound to perfectly functioning vision (e.g. flying). Even partial impairment of vision that can be caused by any one of many known eye diseases, always has far-reaching consequences because compensation by other senses (including olfactory and acoustic sensory perceptions) is usually insufficient, if possible at all. Hence ornitho-ophthalmology occupies an important position in avian medicine (Murphy, 1987; Korbel, 2000; Kern, 2007; Korbel and Bohnet, 2007; Korbel and Weise, 2007).

In bird medicine it still seems to be quite uncommon to examine the eye as a routine part of the physical examination. This contrasts starkly with the generally acknowledged fact that, among the representatives of the class of Aves, ocular lesions may be a particularly strong expression of systemic disorders - to a much larger extent than, for instance, in mammals. Therefore, the objective of the following paper is to present a synopsis of the routine ophthalmological examination procedure and important systemic disorders in bird patients that are either pathognomonic for certain disorders or, when considered in conjunction with other organic diseases, enable a specific diagnosis to be arrived at.

SIGNIFICANCE OF VISUAL CAPACITIES

Visual function in birds is essential for flying, surviving in the wild and reproduction. The eye as the main sense organ in birds and its visual capacities have no general superiority compared to mammals but shows a highly specialisation as an adaption to living conditions. Thus visual acuity is 2 to 8 times higher compared to mammals, visual fields are up to 360°, stereopsis ranges from 0° to 70°, maximum spatial frequence (the ability to dissolve a certain movement into single frames) is up to 160 frames/sec (10-15 in man) and minimum detection of movements is up to 15°/hour (very slow movements). It should be recognized that ultraviolet-perception (UV-perception between 320 and 680 nm), an ability common in diurnal birds bound to special UV-sensitive rods within the retina and an aspect not investigated very well to date, plays a very important role in inter- and intraspecific communication based on plumage-UV-reflection, even in birds which appear monomorphic to the human eye, for the identification/assessment of fruit ripeness based on varying UV-reflection of fruit wax layers, or for camouflage. On the other hand even complete blindness is not a reason for euthanasia in pet birds. Thus, canaries, suffering from blindness due to cataract formation - a condition which occurs quite often in this species - act normally, as long birds as long as the interior of the cage or aviary is not modified.

ANATOMICAL PECULIARITIES

Though there exist numerous anatomical and physiological difference - like the striated rather than smooth intraocular musculature, the *anangiotic fundus oculi*, the *pecten oculi* - basically the approach to avian ophthalmology is quite similar to that employed in mammalian ophthalmology. Some anatomical peculiarities with relevance for the ophthalmologist are:

1. **Size and weight of the avian eye**
   - Axial length 8 mm (Kiwi, Aptery sp.) up to 50 mm (Ostrich, Struthio camelus)
   - Weight (oculus sinister (OS) and oculus dexter (OD) in man 1 %, fowl 7 % (adult) resp. 12 % (juv.) compared to overall head weight

2. **Shape**
   - Determination by anulus ossicularis sclerae (10 – 10 single bony platelets)
   - Flat type (diurnal birds with narrrow heads, for example columbifomes)
   - Conical type (diurnal birds with broad heads, for example falconiformes)
   - Tubular tye (nocturnal birds, for example strigiformes)

3. **Adnexal structures**

   a. Eyelids
      - Palpebra inferior larger than palpebra superior (exclusive owls)
      - Lower eyelid with “tarsus”, no meibomian glands
      - Membrana nictitans highly motile, regulation of praecorneal tear film, protective function for cornea, “snorkel masc effect“ (compensation for loss

of refractive power during underwater vision)

b. Lacrimal glands
   - Small or absent glandulae lacrimaliae
   - Large glandula lacrimalis membranae nictitantis (vel. Harderian gland)
   - Replacement by nasal salt gland (aquatic species)

c. No musculus retractor bulbi
d. Complete decussation of chiasma opticus (no consensual pupillary reflex)

4. **Anterior eye segment**

- Striated intraocular musculature (highly motile iris corresponding to external stimuli, no sensitivity to parasympatholytics/sympathomimetics, no reliable pupillary reflex corresponding to light stimuli)
- Fundus diameter much larger than pupil diameter
- Ligamentum pectinatum/ciliary cleft with species specific peculiarities
- Lens with anulus pulvinus ("Ringwulst"), accommodation range 2 (owls) up to 80 (waterfowl) D

5. **Posterior eye segment**

- Avascular (anangiotic) retina
- Afoveate, uni- or bifoveate retina
- Rods and cones (inclusive special UV-cones) in functional units
- UV-sensitive cones in most diurnal birds
- Slight retinal pigmentation in nocturnal, heavily pigmented retina in diurnal birds
- No retinal tapetum lucidum
- Pecten oculi
- Chorioidal, heavily pigmented structure
- Protruding into the vitreous
- Obscuring papilla nervi optici
- Pleated, vaned and conical type
- 32 functional theories: nutritive, thermo- and pressoregulative function most obviously

OPHTHALMOLOGICAL EQUIPMENT AND EXAMINATION PROCEDURE

Minimum requirement for basic and general purposes
- Focused light source with magnification lens ("Finoff transilluminator")
- Instrumentation for manipulation of the eye lids (Graefe hook)
- Lacrimal cannula (Anel)
- Topical anaesthetics: Proxametacain, Oxybuprocain (duration of action approx. 7-8 min.) or Lidocain (duration of action approx. 17 minutes)

Advanced Equipment
- Slit lamp (magnification x 5 – x 15, better x 20)
- Monocular direct ophthalmoscope with 15 D lens or even better

- Head band ophthalmoscope with 30 and 78 D lens (additional aspherical 40, 60, 90 D)

General examination procedure - Adnexal structures and anterior eye segment

- Without restraint
  - Assessment of visus via food intake, reluctance to fly, orientation
- With restraint
  - Examination of the ear opening
  - Pupillary reflex
  - Examination of the anterior eye chamber with lateral illumination
  - Examination of the anterior eye chamber with lateral transillumination
  - Examination of the anterior eye chamber with retroillumination

Equipment and procedure for specific examinations

- Slit lamp biomicrography
- Gonioscopy (Lovac lens), examination of the angulus iridocornealis with the pectinate ligamentum. Aetiological assessment of primary/secondary glaucoma status.
- Tonometry. Estimation of the intraocular pressure (IOP). Use electronic short time acting tonometer or Schioetz – Tonometer in raptors. Standard reference values measured with an electronic tonometer calibrated for avian eyes, range from 9 to 22 mg Hg and are available for 42 species from 7 orders. Standard reference values for psittacine birds range from 12 – 15 mm HGg for nocturnal birds from 9 – 12 mm Hg, for various poultry species intraocular IOP values are as high as 22 mm Hg. Minimum corneal diameter for reliable value is 9 mm. Reference values for newly developed tonometers (Tonovet[R] and Tonolab[R]) will be available soon.
- Schirmer-Tear-Test. Test for the estimation of the lacrimal function. Use standardised filter strips of 2, 3 and 5 mm width. Standard reference values using filter strips of various width for 42 species from 7 orders showing a wide range of interspecific variations are available. Strigiformes show conspicuously low values.
- Electroretinography. Measurement of retinal function by recording electrical potentials after light stimulation. This technique gives no information about the visus, only on retinal function. Basic principles of electroretinography for routine examination have been established. Indications are retinal disorders and diotric apparatus opacities.
- Laboratory examinations include bacteriological examination of the conjunctival flora. Physiological bacterial flora contains Gram positive bacteria, while Gram negative bacteria are an indication of pathological conditions. Standard reference values have been worked out for 42 different bird species from 8 orders.

MYDRIASIS AND AIR SAC PERFUSION TECHNIQUE (APA)

Induction of mydriasis is indispensable for the examination of the posterior eye segment (ophthalmoscopy). A major difference between the mammalian and the avian eye however is that the commonly used mydriatics of atropine and tropicamide have little effect in the avian patient due to a striated rather than smooth intraocular musculature. Therefore the iris is partly unter voluntary control. It is essential to have a dilated pupil (mydriasis) to perform an ophthalmoscopy, i. e. examination of the posterior eye segment including the vitreous, the fundus and the pecten oculi. Therefor neuromuscular blocking agents such as d-Tubocurarine (3%; 0,01 - 0,03 ml; 1) may be used.

As the drug penetrates the cornea insufficiently it has to be administered directly into the anterior chamber by paracentesis using a 27 - 30 gauge needle. This technique includes substantial risk for injuries of intraocular structures causing i. a. hyphaema, increasing intraocular pressure (IOP), transmission of conjunctival flora with consecutive uveitis and systemic side effects if larger doses than recommended are used. Therefore it is recommended to use this technique just for therapeutical reasons (prevention of posterior of anterior synechia resulting from uveitis and consecutive miosis).

An alternative for routine induction of a mydriasis as well as for intraocular surgery and surgery in the head area is the air sac perfusion anaesthesia. In principle APA consists of a retrograde perfusion of the lung-airsac-system through a perfusion catheter via the left caudal thoracic airsac. As a carrier gas 0,3 l/min/kg BW of O2 is used. Effect of nitrous oxide application are a low potentiation of isoflurane of approx. 11 % and thus improvement of the circulatory situation and release of the surgeon from isofluran waste gases. Higher perfusion rates than recommended result in respiratory alkalosis due to a CO2-wash-out-effect causing severe cardiac arrhythmias. Isoflurane maintanence concentrations vary - dependent of different bird species - between 1,0 Vol. % to 2,4 Vol. % (Columba livia Gmel., 1789). Pulsoximetry is indispensable as APA causes a reversible apnoea due to reduced CO2 partial pressure causing a missing stimulation of the respiratory centre. Advantages of APA, a long period anaesthesia, which is used for routine ophthalmoscopy, electroretinography and head surgery in birds, are free surgical access to the head for intraocular surgery, stable or decreasing intraocular pressure and reversible apnoea with an absolute immobilisation of the patient. Archievement of mydriasis for ophthalmoscopy may be optimized by systemic administration of 0,2 mg/kg BW of the muscle relaxant Vecuronium which allows a complete mydriasis and areflexia with a lag period of approx. 26 sec. and a duration of 25 6 min. in pigeons (*Columba livia* Gmel., 1789) and a reduction of isofluran comsumption of approx. 25 % at the same time. This technique allows examination even of the very lens periphery with the annular pad and the extreme fundus periphery.

APA - PRINCIPLES

- Anaesthesia induced mydriasis and free surgical access to the head area
- Perfusion of lung-airsac-system with oxygen-(nitrous oxide)-isoflurane or sevoflurane mixture
- Retrograde perfusion via left caudal thoracic air sac using a specific air sac catheter
- Induction of a reversible apnoea due to lowering of the CO_2-partial pressure with subphysiological values (below 48 mm Hg; no stimulation of respiratory center)
- Modified anaesthetic machine with low flow flowmeter (0.01 – 0.5 l/min)

APA – Performance

- Carrier gas O_2
- Induction: Head chamber
- Maintanance: Air sac catheter
- Isoflurane concentration: 1.0 - 2.7 Vol.%
- Monitoring: Pulse oximetry (!, no respiratory movements), reflex score, blood gases, body temperature

APA – Advantages

- Routine method for ophthalmlogy and head surgery
- Benefits of inhalation anaesthesia and long period anaesthesia

- Free surgical access to the head
- Stable or decreasing intraocular pressure (IOP)
- Reversible apnoea – absolute immobilisation of the patient
- Achievement of mydriasis for ophthalmology

OPHTHALMOSCOPY IN BIRDS

Ophthalmoscopy, a technique to examine the fundus oculi (a clinical term, describing ocular structures, which are situated behind the lens) using a focussed light beam reflected from the fundus, can be carried out by both monocular and binocular and direct or indirect ophthalmoscopy in combination with double aspherical ophthalmoscopic lenses (at 30, 40, 60, 78 and 90 diopters (D, Volk Bio II) refractive power. In all cases indirect binocular ophthalmoscopy using a head ophthalmoscope is advisable. A 30 D lens is used in birds with larger pupil diameters (nocturnal and diurnal raptors), ophthalmoscopy of pigeons and larger psittacine birds requires an 78 D lens, those in small birds (canaries, budgerigars) the use of a 90 D lens. Alternatively, monocular indirect ophthalmoscopy may easily performed in all birds, especially in smaller species. It should be pointed out that within a long term survey including more than 32 % of traumatised birds showed haemorrhages in the vitreous body originating from lesions of the pecten oculi. Thus ophthalmoscopy is obligatory in traumatised birds.

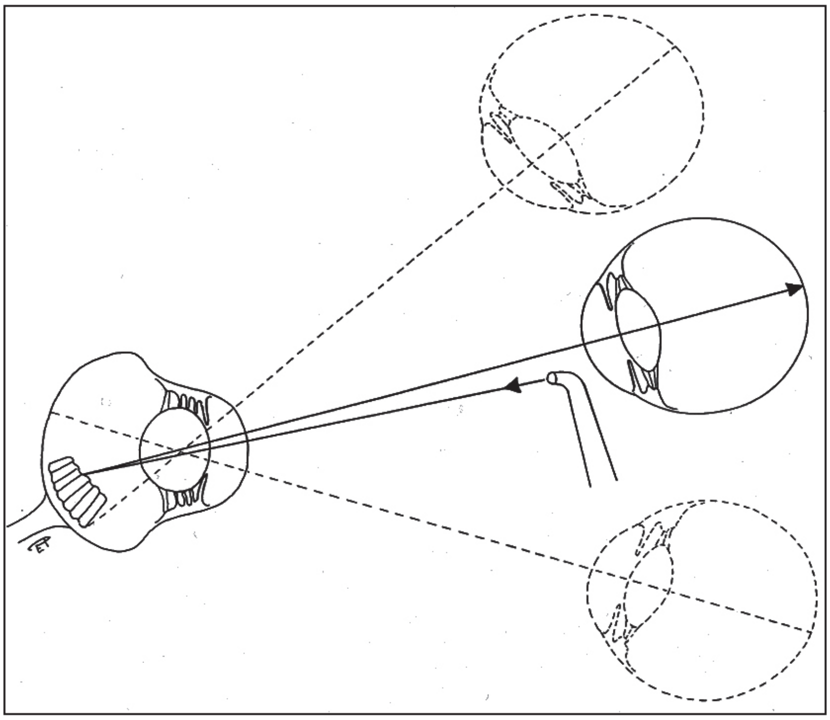

Fig. 1: Optical principles of the (monocular direct) ophthalmoscopical examination of avian eyes. Per definition “ophthalmoscopy” is the examination of ocular structures situated behind the lens, using a focused light beam directed through the pupil and performing the examination using light, reflected from the fundus oculi. As a rule, a nearly coaxial direction of the light beam directed through the (dilated) pupil (Mydriasis) of the patient’s eye (left) on the one hand and the reflected light beam from the patients fundus to the examiner’s eye (right; viewing axis) on the other hand is indispensable in order to project an image on the examiner’s retina (Taken from Korbel and Bohnet, 2007).

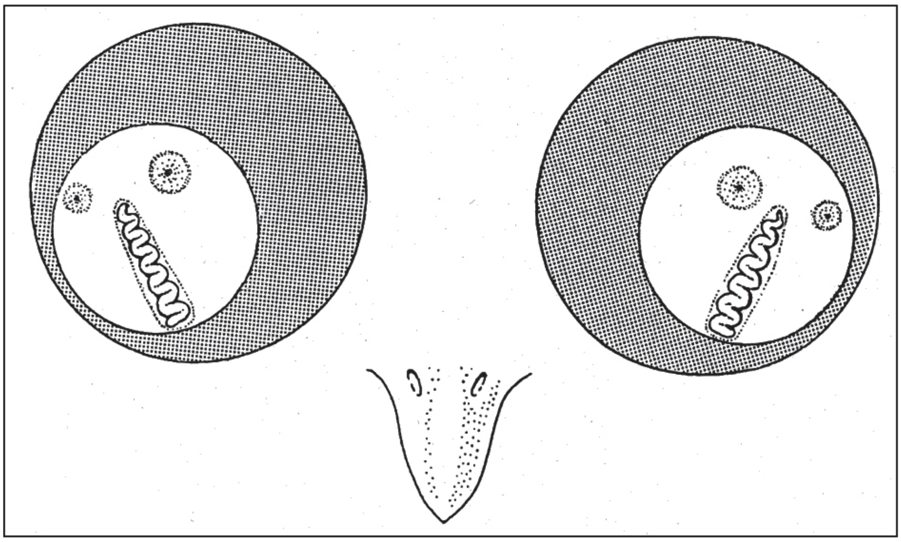

Fig. 2: Topograpical landmarks within the avian fundus with the pecten oculi and the central and temporal fovea. Accessible viewing field (bright area) using monocular direct ophthalmoscopy (taken from Korbel and Bohnet, 2007).

OCULAR DISORDERS IN BIRDS

The ophthalmologist considers it logical to classify eye disorders according to the various ocular structures involved. Thus a complete review on avian ophthalmology discords based on a morphological basis will be given within the presentation, for a literature review please refer to 1, 2, 3 and 4. Within a long period investigation on ocular disorders in birds (2) an overall incidence of 7.6 % of all the birds examined has been found. The highest incidence of eye disorders compared with other patient groups was generally found among wild birds (11.7 %), among which most eye disorders were seen in Accipitriformes (26.1 %), Strigiformes (20.0 %), and Falconiformes (19.7 %). In contrast, a lower incidence was found in falconry raptors with 7.3 %, but again Accipitriformes (6.3 %) were most frequently affected by eye disorders, followed by falcons (5.5 %) and owls (5.0 %). Among disorders of the posterior eye segment (fundus oculi) most often trauma related haemorrhages (most frequently arising from the pectin) may be diagnosed. In general chronic lesions caused by disorders located within the upper part of the fundus are resulting in a poor prognosis, as birds and especially raptors are orientating themselves primarily using the upper part of the fundus (with the central and temporal fovea included).

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