Avian ophthalmology

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SUMMARY

Ophthalmology of birds has become an important part of avian medicine. The principal groups of birds that veterinary ophthalmologists examine in their consultations include cage birds, sport, zoo and wildlife birds. Knowledge on anatomical and physiological peculiarities of the eyes of these species will help in the interpretation of the ocular investigation and in reaching appropriate diagnoses. Some of the most important differences that can be outlined in bird eyes, compared to mammal eyes, include the small ocular size of some species and different morphologies of the eyeball depending on the species. Likewise, the open orbit, voluntary contraction of the pupil (striated sphincter muscle of the iris), ossicles in the sclera, avascular retina and the presence of the pecten protruding into the vitreous chamber (vascular structure that nourishes the retina). Ophthalmic investigation includes a physical ocular examination and complementary techniques, such as tonometry, ophthalmoscopy, electroretinography and ultrasonography, among others, in order to identify the ocular lesions and to evaluate the severity. The most frequent ocular diseases reported include malformations (palpebral agenesia, microphthalmia, cataracts), primary or secondary inflammatory diseases of the eyelids and conjunctiva (poxvirus, chlamydia), trauma (ocular haemorrhages, uveitis, cataracts, chorioretinitis), neoplasms and nutritional disorders (vitamin A deficiency).

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INTRODUCTION

Over the last 20 years birds have become an important part of veterinary ophthalmology consultations, not only because they are frequently kept as pets, but also because there is an increasing awareness of the environment and the conservation of nature and its species. Good vision is especially important in birds due to the direct influence on flight, feeding and breeding.

The principal groups of birds include: domestic birds (Psittaciformes: macaws, parrots, parakeets, cockatoos, nymphs; Passeriformes: canary, mine), those living in zoological gardens (Psittaciformes: parrots, parakeets) and wild birds (Anseriformes: ducks, geese, swans; Falconidae: falcons, sparrow-hawks, eagles; Strigidae: eagle owl, barn owls) and those used in sport (Columbiformes: pigeons).

Prevalence of ocular diseases in birds, has been reported to be 7,6 %, and in the case of birds of prey, it is even higher, up to 14 - 26 % [2, 22]).

Basically, the morphology of the birds eyes, as well as their physiology are similar to that of mammals, though certain peculiarities exist that must be considered in order to carry out a correct interpretation of the ocular examination. In addition, it is important to consider that systemic diseases with ocular signs are just as important in birds as in mammals.

Generally, to allow a precise diagnosis, the same methods and equipment for ocular examination that are used in mammals are also used in birds, though with the limitations of the small ocular size of some birds.

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Fig. 1 The skull of an owl illustrating the orbit with tubular shaped exposed eye.
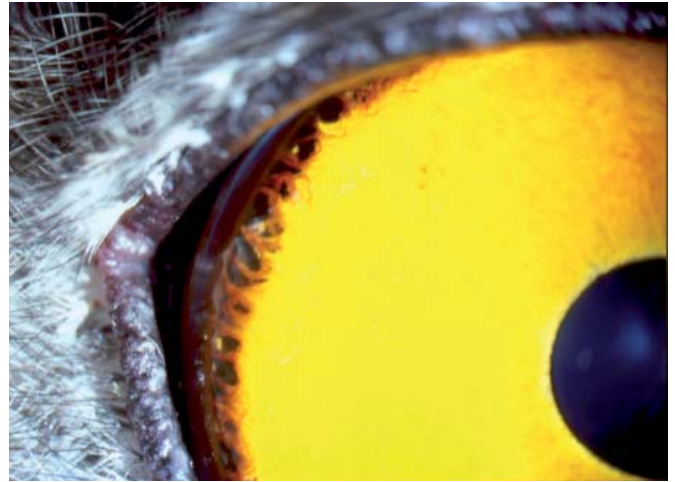

Fig. 2 Iridocorneal angle of an owl

This paper describes the anatomical and physiological characteristics of the bird's eyes, methods of ocular examination and the most frequent ocular diseases.

Characteristics of birds visual function

The sensory organ of vision in birds is highly specialised for adjustment to their living conditions, their visual acuity being 2 to 8 times higher than that of mammals. Their visual fields are up to 360 °, the range of stereopsis is 0 ° to 70 °, the maximum spatial frequency (skill to distinguish a certain movement in simple images) is over 160 images / second (10-15 in humans) and a minimal detection of movements over 15 °/hour (movements that are performed in a very slow way) [6, 21].

The perception of ultraviolet light is a common skill in the diurnal birds due to the rods in the retina having a special sensitivity to ultraviolet light. This ability plays a very important role in features like bird communication, camouflage and orientation [6].

Anatomy and ocular physiology

Orbit and globe
The globe is big compared to body size, with a posterior segment disproportionately larger than the anterior segment (Fig. 1). The back of the globe fits narrowly in the orbit, though many temporal and dorsal zones are unprotected by bone. The diameter of the equator of the globe exceeds the diameter of the anterior bony orbital rim in many species. The orbits are separated only by a thin bony structure or a septum of connective tissue [22].

The shape of the eyes is supported by the 10 to 18 scleral ossicles in the intermediate segment, as well as by the hyaline cartilage present in the posterior segment of the sclera. There are three basic shapes of the eyeball [15, 39]:

Flat: presenting with a short antero-posterior axis, flat or concave ciliary region, convex cornea and hemispherical posterior segment, this is typical of the majority of birds.
Globose: the ciliary region protrudes further from the posterior

segment though remaining concave . Globose shape is typical for many diurnal birds, since they need high resolution for long distances (diurnal birds of prey, insectivorous, ravens ...).
Tubular: in which the intermediate concave segment elongates anteroposteriorly, forming a tube, before joining the posterior segment at a sharp angle. The cornea is at the front. This shape is typical of owls (Fig. 1).

The extraocular muscles are rudimentary, thus ocular motility is limited in comparison with mammals. There are 4 straight muscles, 2 oblique ones, 1 pyramidalis muscle and 1 quadratus muscle (they replace the retractor bulbi muscle in mammals, which are innervated by cranial nerve VI and move the nictitating membrane). Portions of Ist-VIth cranial nerves have an intraorbital course, with the optic nerve being quite short. The vascular plexus is in the ventrolateral zone of the orbit [15, 39, 18].

The infraorbital sinus and part of the cervicocephalic air sac system are situated laterally, subcutaneous to the nasal area and rostroventral to the eyes in several groups of birds (psitacidas, storks ...). The sinus can be connected with pneumatised sections of the skull bones that spread towards the upper parts of the beak, jaw and orbit [15, 39].

Eyelids and ocular annexes
Birds have an upper and a lower eyelid plus a nictitating membrane. The lower eyelid is more mobile than the upper one, which allows it to cover a larger part of the eye during blinking. It also has a fibroelastic tarsal plate. Near the palpebral margin there are modified feathers for protection or for tactile function. On hatching, eyelids are well developed and the palpebral fissure is open in precocial birds (species in which the young are relatively mature and mobile from the moment of hatching) while the lids are sealed together and incompletely developed in altricial birds (species hatched with lack of hair or down, and which must be cared for by the adults). The time of opening of eyelids in altricial birds is variable: in the case of cockatoos it happens between 10-17 days after hatching and in macaws 17-26 days. The palpebral separation starts centrally, progressing

medially and laterally. There are no meibomian glands at the tarsal edge of the eyelids [15, 39].

The nictitating membrane is well developed and mobile; it is thin and translucent and moves over the globe from a dorsonasal position towards a ventrotemporal position, dragged by the pyramidal muscle that originates from the back of the sclera turning around the optic nerve and passing through a sling formed by the quadratus muscle. The temporal top edge of the nictitating membrane is firmly adherent to the underlying sclera and is associated with the conjunctiva; while the pyramidalis tendon is inserted along the lower nasal edge. The free edge of the nictitating membrane has a marginal pigmented fold or edging that facilitates the distribution of tears over the ocular surface during blinking]15, 39].
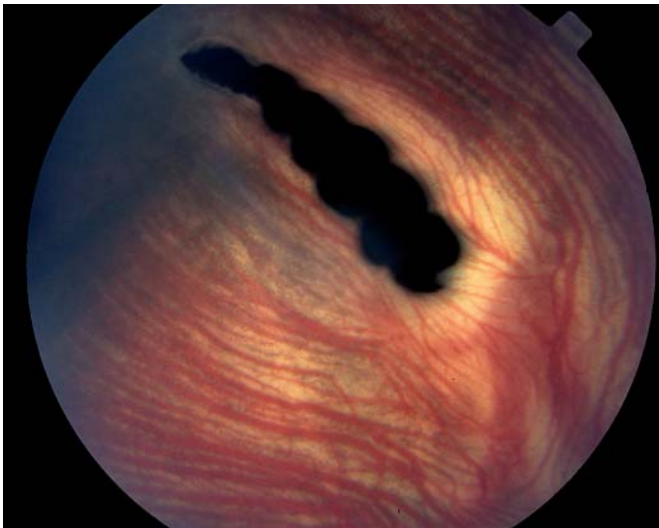

Fig. 3 Typical fundus oculi of a nocturnal raptor: the choroidal vessels overlying the white sclera and the ventronasal periphery of the pecten.

The Harderian gland, situated near the base of the nictitating membrane, is the main source of tears in birds. A wide canal, runs from the gland and opens inside the conjunctival sac between the eyeball and the nictitating membrane. The lymphoid tissue associated with the conjunctiva, together with the Harderian gland plays an important role in the humoral immunological defence of the ocular surface. The lacrimal gland is positioned inferotemporal to the globe (absent in penguins and owls). In some birds, such as budgerigars, a nasal or salt gland lies in the orbit dorsomedial to the globe. The duct of this gland penetrates the frontal bone and enters the nasal cavity.

Anterior segment
Birds' corneas are histologically similar to those of mammals. The lens is soft and almost spherical in nocturnal birds, or has a flattened anterior aspect in diurnal species, including companion birds. An annular pad lies under the lens capsule in the equatorial region, and can be separated from the centre of the lens during cataract surgery. The power of the lens can be increased by contraction of the mid-striate ciliary muscles (Brucke

and Cramptons muscles), which compress the annular cushion [15, 39]). The ciliary processes are attached to the equatorial lens capsule. Crampton's muscle has connections with the peripheral cornea, being able to produce changes in the corneal curvature when it contracts. In several diving birds, the changing shape of the lens produced by miosis is part of the accommodation. The iris is generally brown, though other colours can also be present. The stromal pigments of the iris are composed of carotenoids, purines and pteridines; in some species the coloration of the iris can change with age and sex. In red tail falcons there is a colour shift from yellowish to grey when the birds reach 4 years of age; in araraunas the iris changes from brown to grey when the birds are one year old; in Amazons the iris changes from brown to red or orange when they grow up; in cockatoos there is sexual dimorphism, the females having a red coloured iris and males dark brown or black, while in the young cockatoos the iris is brown in both sexes.

The iris muscles are mainly striated, with smooth muscles appearing only in smaller proportion. This allows voluntary contraction of the pupil. The striated circumferential muscle seems to be the primary pupillary sphincter in all species. The circular pupil responds rapidly to accommodation and voluntary control, as seen for instance in stress during handling. There is a direct pupillary reflex, but no consensual one, due to the complete decussation of the optical nerve axons. A small degree of anisocoria can be normal. The iridocorneal angle is well developed (Fig. 2) [15, 25, 39].

Posterior segment
The vitreous body is large and transparent. The fundus is normally grey or reddish in colour, with the choroidal vessels not always visible. The optic disc is long and oval, but it is often difficult to observe on ophthalmoscopy due to the pecten. The pecten is a vascular prominence emerging from the retina and protruding into the vitreous, of variable comb-like shape and black in colour (Fig. 3). It is involved in the nutrition of the retina and plays a role in intraocular acid – base balance, production

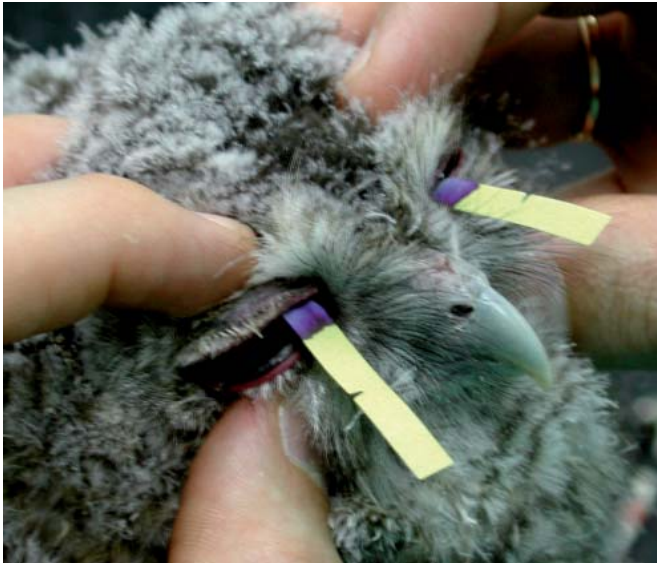*Fig. 4 Biomicroscopy examination in a duck.*

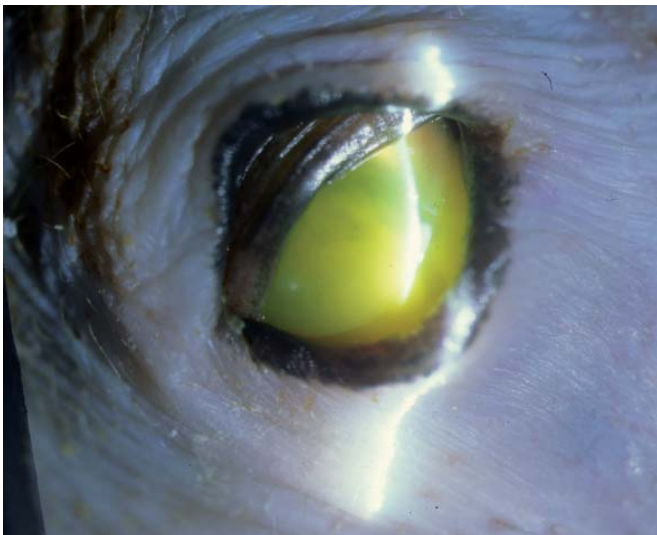*Fig. 5 Schirmer tear test in a little owl.*

Fig. 6 Corneal ulcer stained with fluorescein in a jaco.
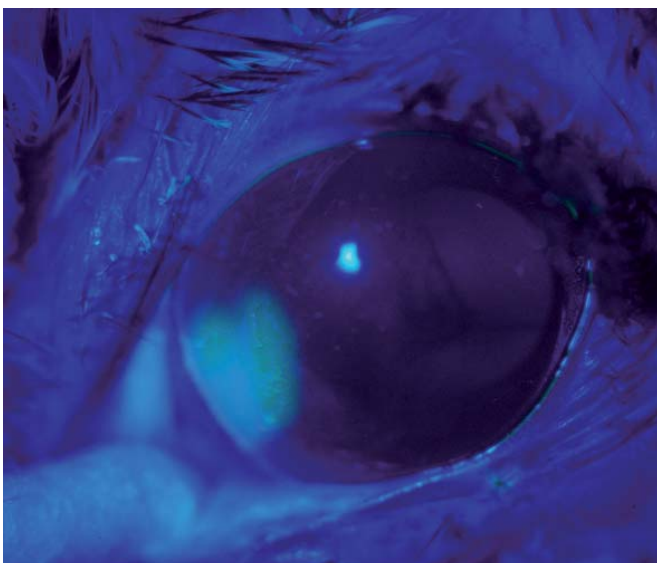

Fig 7. Corneal ulcer stained with fluorescein and examined with cobalt blue light.

of intraocular fluids and mechanically shakes the vitreous fluid during ocular movements, facilitating the movement of fluids inside the eye [4]).

The retina is avascular and without a tapetum. The type of photoreceptors and the density vary among birds, but generally rods and cones or double cones with oil droplets are present. According to the specialisation of the retina to enhance the resolution or sharpness, birds can be classified as:

Afoveate. These have an *area centralis* or visual line usually present when there is absence of fovea), seen in the majority of the domestic birds and some birds of land and water.
Monofoveate, having a central (majority of birds) or temporal fovea (owls, swifts) with or without a visual line around the fovea.
Bifoveate, with a principal central fovea and a temporal subsidiary, with or without a visual line of enhancement of the sharpness between the foveas (falcons, eagles, several passeriformes, others that hunt during flight).

Colour vision is well developed and several species can detect light in the ultraviolet range [22, 27].

Ophthalmological examination

The ophthalmologic examination in birds is similar to what is performed in mammals with some peculiarities derived from the anatomical and physiological differences. In general, the ocular examination will follow a general examination of the animal. First a complete clinical history must be gathered, as well as a study of the habitat and nutrition. While the clinical history is being taken, it is recommended that the animal should be kept in its cage, in order to evaluate its visual acuity and state of alertness as well as its general behaviour while being under the control of the owner.

Ocular examination:
Inspection: Ideally, the ophthalmologic examination should be carried out without the use of sedatives or anaesthesic agents, since this can interfere with behaviour as well as with lacrimation and reflexes.

The examination of the anterior segment and periocular structures is carried out by means of a beam of light, otoscope with a magnifying glass, direct ophthalmoscope (with a lens of +25D or +40D) and a slit-lamp biomicroscope (Fig. 4). The latter is necessary for examining the small eyes of some species of birds since it allows magnification and visualisation of small injuries. Likewise, expert help in handling birds is useful to hold the animal whilst the clinician works the equipment [15].

Ocular reflexes: In birds the palpebral reflex is evaluated by touching skin areas on the lateral and medial edge of the eyelid. The nictitating membrane goes over the cornea quickly and completely in normal birds; both eyelids will move easily, though the lower one covers a larger area of the corneal surface than the upper one. The globe does not retract and the eyelids may not close completely in normal birds. The direct pupillary light

reflex may be evaluated by the use of a beam of bright light in a dimly lit room [15, 18, 39].

Spontaneous pupil movements may happen due to situations of excitement because of the voluntary control. Indirect or consensual reflexes are not expected in birds due to the complete decussation of the fibers of the optical nerve. However, sometimes small responses can be provoked due to the fact that the eyes are separated by a very thin septum. The menace reaction is weak in birds with normal vision, thus it has very little diagnostic importance. The conjunctional movements of the eyes are minimal in the majority of the birds due to the limited ocular motility [15].

The corneal reflex, though it is not routinely examined in birds, is observed by means of blinking, movement of the nictitating membrane and the negative response to external stimuli; however, the eyeball does not retract due to the absence of the retractor muscles of the globe.

Schirmer tear test: it is carried out mainly in birds of great size (Fig. 5). In a study carried out in 255 birds of 42 species, Schirmer tear test values have been obtained for Psittaciformes, being 3.2-7.5 mm/min without topical anaesthesia and 1.7-4.5 mm/min with topical anaesthesia; in Falconiformes 4.1-14.4 mm/min without anaesthesia and 2-4.2 mm/min with topical anaesthesia; in Accipitriformes 10.7-11.5 mm/min without anaesthesia and 3.6-5.9 mm/min with topical anaesthesia [19, 39].

Staining: Topical fluorescein sodium, together with the cobalt blue light reveals damage to the cornea (Fig. 6 and 7) or possible obstructions in the lacrimal system. Staining with Rose Bengal is carried out for the diagnosis of keratitis (it stains keratinized epithelium) [39].

Cytology and cultures: These procedures may be necessary when an infectious or parasitic problem is suspected (mites in the periocular structures) and there is an ocular discharge. If ocular mucus or mucopurulent secretion is observed, a sterile sample for isolation of bacteria, mycoplasmas or virus is indicated. For the isolation of Chlamydia it is preferable to gather samples from the choanas, trachea or cloaca [15].

The most frequent flora present in the conjunctival sac in psittacines includes Gram positive bacteria (*Staphylococcus epidermidis Staphylococcus aureus*, *β-hemolytic Streptococcus*, *Corynebacterium sp.*); Gram negative bacteria are rare and only reported to be isolated from 1 % of samples [40].

Corneal cytology is indicated in superficial erosions and progressive ulceration associated with infiltrations of inflammatory cells. To take a sample for cytology a topical anaesthetic is instilled (1 or 2 drops). After 60 seconds the sample can be obtained then the smear stained with Giemsa or DiffQuick. One should be aware that in birds topical anaesthetic can cause systemic toxicity and even general anaesthesia.

Tonometry: The equipment used to perform tonometry are Tonopen® (applanation) (Fig. 8), Tonovet ® (rebound) (Fig. 9)

Fig. 8 Tonometry with Tonopen® in a raptor.

Fig. 9 Tonometry with Tonovet®.

Fig. 10 Intracameral injection of d-tubacurarine in a raptor in order to induce mydriasis.

Fig. 11 Indirect ophthalmoscopy.

Fig. 12 Electroretinography in a raptor, showing the placing of electrodes.
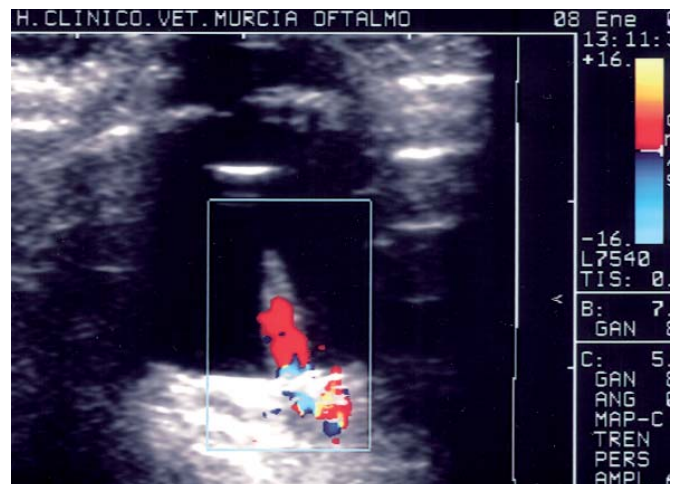

Fig. 13 A Ultrasonography of a raptor's eye showing normal ocular structures. B. Color Doppler Ultrasonography showing blood flow in the pecten (arrow). L, lens.

and Schiötz tonometer (indentation). In birds, the normal values of intraocular pressure are as follows : In turkeys, 25 mm Hg (applanation); in birds of prey, 11-16 mm Hg and in psittacines 20-25 mm Hg (applanation). In the study carried out by means of Tonopen in 275 normal birds of 39 species the range of values is between 9.2 and 16.3 mm Hg. The reproducibility of the values is obtained with corneal diameters ≥9 mm, being limited in corneal diameters <5 mm (20, 35). In large birds and by means of the Schiötz tonometer, values of 15-17 mm Hg have been obtained in falcons and 20 mm Hg in hens. Also the Tonovet has been used in another study with 31 birds of prey, obtaining a range of measures from 9 mmHg in small raptors and 40 mmHg in large birds of prey [3].

Direct and indirect ophthalmoscopy: The mydriasis necessary for ophthalmoscopy in birds can be obtained by means of general anesthesia with ketamine or by topical or intracameral tubocurarine (d-tubocurarine chloride®, Sigma Chemical CO) (20

mg/ml) (Fig. 10) (1, 22). A study in raptors proved the efficiency of three curariform agents, obtaining the following results (25): Vecuronium bromide topically (2 drops every 15 minutes): the maximum reaction appears immediately after application, and is effective for 4 hours .Alcuronium chloride causes mydriasis of 3 hours' duration, though in the study the majority of the birds presented with palpebral paralysis and even paralysis of the neck and hindlimbs in some birds. Pancuronium bromide produces a very slight reaction.

Direct ophthalmoscopy is used most frequently, though it is not the best in exotic birds, due often to the small size of the eyes and also to the fact that the head of the clinician must be close to the bird. When an injury is suspected, the indirect ophthalmoscope can be used, since it allows exploration of a very wide area of the fundus (with a reversed image) at a larger distance from the clinician (Fig. 11). The lens required depends on the size of the birds, from 20D-30D in large birds up to 90D
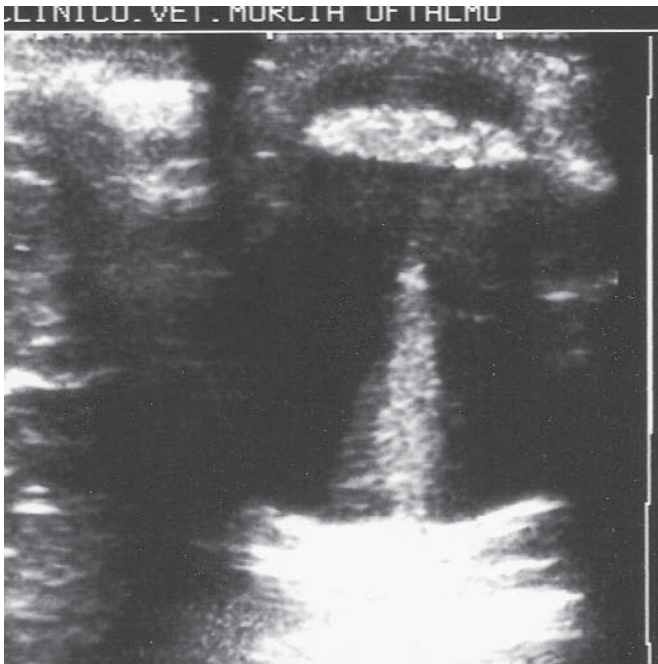
Fig. 14 Ultrasonography of a raptor with cataract, showing a hyperechogenic lens (L).

Fig. 15 Poxvirus in a canary.

in small species. The fundus of both eyes must be compared, especially when some anomalies are present. The optic nerve head is most often hidden under the pecten.

Fundus camera allows us to document posterior segment diseases, including fluorescein angiography in large species. In very small eyes the focal distance is not suitable.

Electroretinography is used for assessing retina function. It is carried out on animals anesthetised by means of an intramuscular combination of ketamine-medetomidine or by means of inhalation anaesthesia, such as isofluorane. The authors carry out the procedure by means of the same equipment as used in mammals with a contact lens, monopolar Dawson Trick Litzkow (DTL) fiber electrode (in very small eyes) and dermal electrodes. The protocol is similar to the one established for dogs [28].

BD and Doppler ultrasonography (Fig. 13A and B): in

ophthalmology this noninvasive technique is used fundamentally for ocular biometry and when the opacification of anterior structures (cornea, anterior chamber, lens) prevent visualisation of deeper structures (vitreous body and retina) (Fig 14). Likewise, it offers information about diseases of the orbit (neoplasia, foreign bodies). It can be carried out with general equipment or special equipment for ophthalmology using linear transducers of high frequency (7.5-11MHz). Colour Doppler ultrasonography allows evaluation of vascularisation of the ocular structures.

Radiology is used in ophthalmology prior to other visual techniques (ultrasonography, axial computerized tomography and magnetic resonance) for the evaluation of the orbit and cranium [15].

Axial Computerized Tomography provides detailed images of the structures contained in the orbit (eyeball extraocular muscles, optic nerve), as well as of the bones. It gives important information for the diagnosis of orbital neoplasms, inflammatory and traumatic diseases.

Magnetic resonance: In small animals it is used fundamentally in neuroophthalmology, due to the good resolution that it provides for the evaluation of the soft tissues.

Ocular diseases

Congenital diseases

Palpebral malformations described (though infrequent) have been partial agenesis of the top eyelid in birds of prey (peregrine falcon) [16] and ankyloblepharon and cryptophthalmos (merging of the eyelid margins) in nymphs [7].

The presence of microphthalmia can be the result of congenital malformation or acquired phthisis bulbi. Bilateral microphthalmia has been described in ducks, bilateral anophthalmia in budgerigars and microphthalmia with presence of cataracts, retinal dysplasia and retinal detachment in birds of prey [8, 15]. Phthisis bulbi has been observed frequently secondary to uveitis, but is less evident than in mammals due to the presence of the scleral ossicles. Therefore, the differentiation between microphthalmia and phthisis depends on the clinical history and the ocular examination [15, 39].

Corneal dermoids have been reported in a goose, in which feathers grew out of the aberrant dermal tissue on the lateral aspect of the globe. Unilateral corneo-conjunctival dermoid was successfully removed from a blue-fronted Amazon parrot [39].

Ectropion and secondary exposure keratitis has been reported in cockatiels.

Exophthalmos

Orbital diseases that cause exophthalmos are infrequent in birds. If present, the anterior displacement of the globe can be due to orbital trauma (fractures of the cranium); inflammation (orbital post traumatic haemorrhage - very infrequent in birds compared to mammals), inflammation of the Harderian gland in psittacines, infections such as orbital abscesses that

Fig. 16 Periocular swelling associated with infraorbital sinusitis in an African Grey Parrot.

Fig. 17 African Grey parrot with chlamydial conjunctivitis.

spread from the paranasal sinuses in Amazon and African grey parrots, neoplasias such as lymphoreticular neoplasms, adenocarcinoma and osteosarcoma in budgerigars, glioma of the optical nerve, sarcomas, chromophobe pituitary adenoma and medulloepithelioma in nymphs [1,11,30,32].

Treatment in cases of trauma and inflammatory diseases should include systemic corticosteroid and anti-inflammatory drugs and systemic and topical antibiotics (bacitracin-neomycin-polymyxin B). If an orbital abscess is suspected systemic antibiotics should be administered for 14 days. If this therapy fails to improve the condition, an alternative antibiotic or reassessment of the aetiology of the exophthalmos should be considered [15, 18].

If neoplasia is suspected or proved by biopsy or aspirate tests, exenteration of the orbit is recommended, with enucleation and removal of all orbital soft tissues. Before surgery, one should assess the likelihood of metastasis or an association with primary systemic disease or neoplasia elsewhere. Work-up should include abdominal and thoracic radiography, haematology and serum chemistry testing [15, 18].

Periocular swelling
Local or diffuse periocular swelling can progress from pathologies that involve the eyelids, conjunctiva, infraorbital sinus or nasal gland (in birds that have them).

Eyelid disorders can be of traumatic or infectious origin, and include lacerations, haemorrhages and abrasions. The most frequently described causes of infectious eyelid diseases are the following: blepharoconjunctivitis due to *Staphylococcus* in Amazon parrots [34], fibrinopurulent blepharoconjunctivitis secondary to *Escherichia coli*, *Streptococcus spp.* [9], *Pasteurella multocida* [29], *Actinobacillus spp.* in waterfowl and *Plasmodium spp.* in canaries, bilateral supraorbital abscesses due to *Pseudomonas sp*p in Amazon parrot [38] and poxvirus in dove, Amazon parrot [12,24,31], canaries (Fig. 15) (14), mines, parrots (31) and birds of prey, blepharitis due to parvovirus in geese

and protuberant lesions for *Cnemidocoptes pilae* in parakeets. Vitamin A deficiency can cause conjunctival hyperkeratosis and swelling of the eyelids similar to that caused by poxvirus [13, 39].

Treatment of poxvirus lesions should include topical antibiotic ophthalmic ointments to reduce the incidence of secondary infections with bacteria or fungus. Systemic antibiotics may also be required in severely affected birds. Early lesions should be flushed with dilute antiseptic solutions. Once scabs have formed they should not be removed. It may be beneficial to soften the scabs, however, with hot or cold compresses soaked in non irritating baby shampoo. It has been reported that prophylactic vitamin A supplementation of exposed birds decreases the severity of infection [15, 39].

Infraorbital sinusitis is frequent in psittacines, causing swelling of the area medial and ventromedial to the eyeball (Fig. 16). It is generally associated with diseases of the respiratory system. The inflammation of the salt gland is seen as puffiness over the globe and can be caused by ingestion of water with high levels of sodium [15].
Palpebral and conjunctival neoplasms are not frequent. A benign tumour of basophil cells has been reported in a parakeet, histiocytic sarcoma in an owl, mastocytoma, cystadenoma in jacos and subconjunctival hibernoma in a goose [39].

Conjunctivitis, keratoconjunctivitis and keratitis
Conjunctivitis can be classified clinically into three groups. The first are those caused by strictly local factors, such as localised conjunctival infection or foreign bodies. The second are those in which conjunctivitis is a manifestation of periorbital or orbital disease. These are mainly related to sinusitis. The third group are those in which conjunctival hyperaemia is caused by a septicaemia. Almost any organism causing systemic infection can result in conjunctivitis. A careful examination of the bird for upper respiratory disease is mandatory in determining the causes of ocular discharge or conjunctival hyperaemia. Exposure

Fig. 18 Corneal degeneration in a Peregrine falcon.

to cigarette smoke, chemical fumes and other airborne environmental toxins should always be considered in the differential diagnostics of conjunctivitis, with or without signs of upper respiratory disease [39].

Conjunctivitis in passerines can be caused by Newcastle virus, paramyxovirus, poxvirus, cytomegalovirus, *Streptococcus spp, Erysipelothrix rhusiopathiae, Clostridium botulinum, Mycobacterium avium* serotype 2, *Escherichia coli, Pseudomonas aeruginosa, Bordetella avium, Chlamydophila psittaci* (Fig. 17), *Mycoplasma spp., Candida albicans, Aspergillus spp., herpesvirus, adenovirus,pneumovirus.*

The most frequent parasites are spirurids (*Ceratospira*, *Oxyspirura*) in psittacines, mynahs; trematodes (*Philophthalmus gralli*), nematodes (*Thelazia* in Senegal parrot; *Setaria* in passerines).

Conjunctivitis can also be secondary to poor hygienic sanitary conditions due to the ammonia from faeces [15,39].
Treatment of conjunctivitis consists of administration of topical antibiotics (bacitracin-polimyxin B, neomycin, tetracycline, chloramphenicol) for 14 days. When respiratory signs exist in addition an antibiotic should be administered parenterally. In case of parasites, these can be removed with forceps under topical anaesthesia. If this is impossible, the use of ivermectin must be considered. Keratoconjunctivitis, a frequent ocular disease in psittacines, can be caused by chlamydiosis, trauma in the cage and deficiency of vitamin A. There have been reported corneal crystalline deposits of unknown cause in 8.7 % of nymphs, parakeets and Amazons on necropsy. These deposits have also been observed in Amazon parrots with poxvirus. Bilateral deposits of cholesterol have been observed in the corneal stroma in falcons (Fig. 18). Punctate keratitis has been described in Amazons associated with sinusitis. The lesions were bilateral, and the most common presenting signs were blepharospasm and clear ocular discharge [15,39]. Keratitis can be difficult to resolve, but, as a rule, topical antibiotics and corneal bandaging techniques provide a sterile environment and time for the corneal epithelium to heal. By extrapolation from other species, anticollagenases should be used in deep ulcers, especially in hotter climates, where corneal melting may be a cause of rupture of the globe. Also, in the case of punctate keratitis as well as antibiotic treatment the use of topical non-steroid anti-inflammatories can be useful [15].

Uveitis
The principal causes of uveitis in birds include trauma, infections, immunemediated inflammation and neoplasia [33,36]. A blunt or sharp trauma can cause anterior and/or posterior uveitis, frequently associated with haemorrhage (Fig. 19A and B). In several studies carried out in birds of prey, hyphema was the most frequent clinical finding, though also findings such as hypopyon, fibrin clots, iridocyclodialysis (tearing of the iris) (Fig. 20), lens injuries and fractures of the scleral ossicles can be
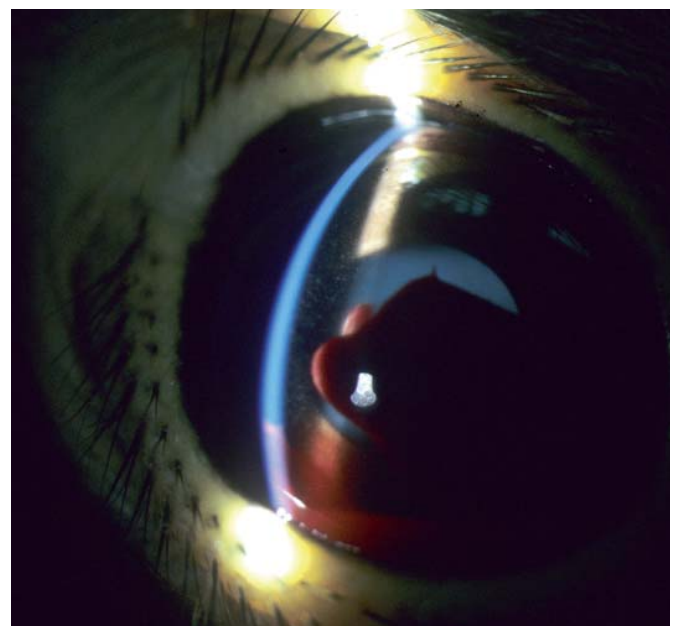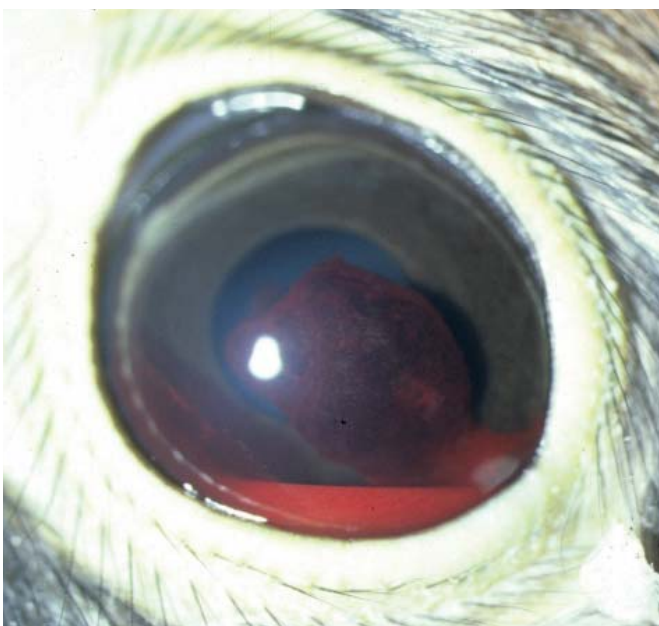

Figure 19. A. Hyphema in the anterior chamber in a raptor. B. The same eye seen with slit lamp.

Fig. 20 Iris rupture in a raptor.

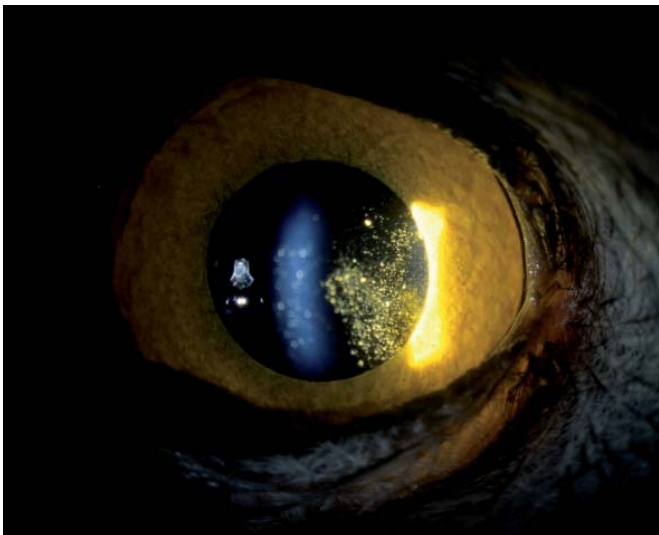Fig. 23 Anterior synechia, cataract and uveitis in an eagle.

Fig. 21 Tyndall effect in an owl with uveitis.

Fig. 24 Traumatic buphthalmos in an eagle.

Fig. 22 Intravitreal haemorrhage and white fibrin clots in a raptor.

Fig. 25 Traumatic cataract in a little owl.

present. Anterior uveitis can also develop secondary to corneal ulcers as in mammals [2,22].

Concerning infectious aetiologies of uveitis, the most important are those secondary to viruses that affect birds, such as encephalomyelitis, Marek's disease and poxvirus. Septicaemia due to any bacterial infection (*Pasteurella multocida, Salmonella, Mycoplasma gallisepticum)* may cause uveitis. Mycotic endophthalmitis has been associated with disseminated aspergillosis and candidiasis in budgerigars. Toxoplasmosis has caused chorioretinitis and blindness in canaries and raptors. Clinical signs of the anterior uveitis in birds include photophobia, blepharospasm, corneal oedema, Tyndall effect (Fig. 21), vitreous opacity, hypotony or secondary glaucoma, miosis, dyscoria, thickening of the iris or discoloration, rubeosis iridis and anterior or posterior synechiae. In posterior uveitis, diffuse or focal retinal oedema, haemorrhages near the pecten, retinal detachment and vitreous opacity (Fig. 22) can be present. The visual function can be diminished or abolished.

Sequelae of chronic uveitis include diffuse corneal oedema, posterior synechiae causing pupillary occlusion and iris bombé, anterior and posterior synechiae (Fig. 23), secondary glaucoma (Fig. 24), cataracts (Fig. 25), retinal atrophy or detachment and blindness (Fig. 26) [10].

Iatrogenic uveitis and reduction in intraocular pressure can be mistaken clinically. The latter can appear during anaesthesia in the same eye of decubitus in psittacines and birds of prey, due to a larger pressure applied on the eye, provoking a forced drainage of the aqueous humour [15].

Treatment of uveitis should include elimination of the cause, control of inflammation, preservation of the pupil and prevention and treatment of secondary glaucoma. Prescribe topical antibiotics and topical and systemic anti-inflammatory agents (steroids and non steroids) for symptomatic treatment of inflammation. It is very important to watch out for systemic side effects (polyuria, polydipsia, etc.). Mydriasis cannot be achieved by topical therapy (e.g., atropine) in birds, and pupil preservation is best accomplished by adequate control of inflammation [15,39].

Glaucoma
Glaucoma can be secondary to uveitis and hyphema (Fig. 24). It has been provoked, experimentally in birds maintained in constant light or darkness. Primary glaucoma is not described in birds due to the width of the iridocorneal angle. Buphthalmia is not very severe in glaucoma, due to the inflexibility of the sclera because of the ossicles. The safety and efficacy of the topical and oral medications, routinely prescribed for mammals for glaucoma, are unproven for birds. In severe cases, enucleation of the eye or placement of a intrascleral prosthesis are the treatments of choice in birds [15,39].

Cataracts
Cataracts in birds are those of congenital type and secondary to nutritional deficiencies, trauma, age (senile cataracts) (Fig. 27) and retinal degeneration [5,15,26, 39].

Ocular development anomalies such as microphakia, development of lenses with abnormal material (lentoids as well as dysplasia and detachment of retina) and hypoplasia of the optic nerve have been described in birds of prey. Hereditary cataracts have also been described in canaries (Fig. 28) with an autosomal recessive model of transmission (Yorkshire and Norwich canaries). Other aetiologies of cataracts include avian encephalomyelitis, maternal vitamin E deficiency, trauma, dinitrophenol (chicks) and chronic uveitis [15, 39].

Lens opacities can be capsular, cortical and/or nuclear. Hypermature cataracts can differ from the incipient ones by their shrinking, capsular wrinkling and the presence of a deeper anterior chamber. Luxation or subluxation of the lens (Fig. 29) can accompany cataract primarily or as a secondary form.

Treatment of cataracts is, as in mammals, by means of phacoemulsification, except for in very small eyes [17]. In birds with very small eyes, complete blindness is not an exclusive reason for the euthanasia since, for example, a canary blind from bilateral cataracts can lead a normal life in its cage, providing that the cage interior is not modified at all.

Retinopathy and optic neuropathy
Retinal diseases include congenital anomalies, degeneration, inflammation and detachment. Congenital retinal dysplasia has been described in birds of prey (falcons fundamentally) [27]. Idiopathic degeneration has been reported in a budgerigar (37). Trauma is the most frequent reason for injuries of the posterior segment (Fig. 22) (26), especially in birds of prey, though it can be associated with bacteraemia or viraemia. The chorioretinitis lesions caused by Toxoplasmosis are easy to identify in birds of prey (Fig. 30) [22].

Optic neuropathy can be associated with congenital anomalies (hypoplasia of the optic nerve associated with cataract), trauma (frequently provoking neuritis), neoplasia (chromophobe adenoma of the pituitary gland causing compression of the optic nerve, atrophy and blindness in parakeets and nymphs). The focal or multifocal retinopathies and the optic neuropathies do not interfere with vision, with only minor change in direct pupillary light reflexes. Wide lesions in retina and optic nerve cause loss of vision, variable degree of mydriasis and a deficiency in the direct pupillary light reflex. Unilateral lesions cause anisocoria. Cataracts frequently develop secondary to retinal degeneration. The signs observed in the retina include depigmentation, hyperpigmentation and loss of the choroidal vascular patterns (Fig. 31). Intraretinal haemorrhages and haemorrhage around the pecten can frequently be observed after ocular trauma, as well as retinal oedema and detachment, which appears as grey and slightly elevated areas. Acute traumatic retinopathy and/or optic neuropathy are treated systemically with broad-spectrum antibiotics and anti-inflammatory doses of corticosteroids [2,15,22,39].

Blindness with normal pupil sizes and responses
Malformations, trauma, infections (bacterial, viral, parasitic and fungal), intoxications (i.e. hexachlorophen causing reversible blindness in parakeets) can cause central nervous system signs

Fig. 26 Traumatic haemorrage and retinal detachment in a raptor.

Fig. 27 Mature cataract in a duck.

Fig. 28 Typical cataract in a canary.

[15]. Clinical signs include variable unilateral or bilateral blindness with normal resting pupil sizes and pupillary light responses. Other reported signs are disorientation, seizures and abnormal behaviour. Therapy should be oriented to treat aetiology (i.e. anti-inflammatory corticosteroid after trauma.)

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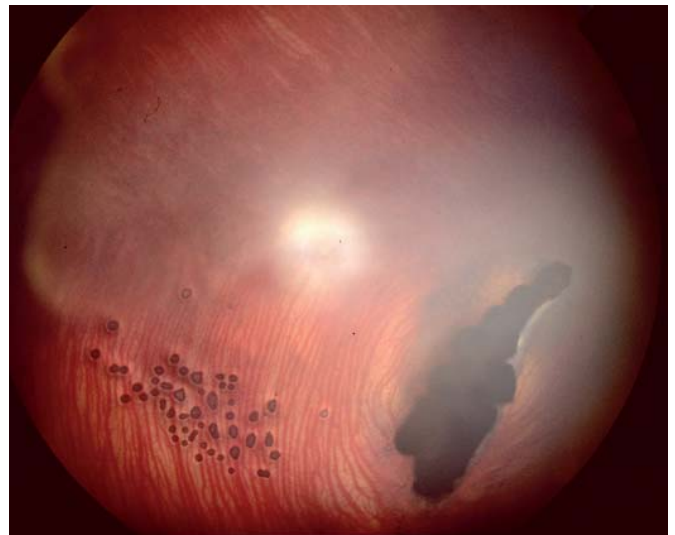*Fig. 29 Lens luxation associated with cataract in a raptor.*
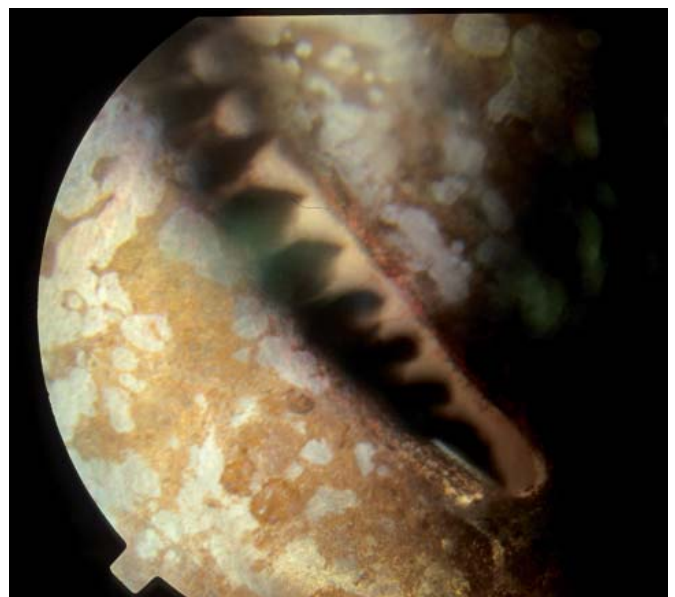

Fig. 30 Chorioretinitis secondary to toxoplasmosis in an owl.

Fig. 31 Retinal degeneration in an eclectus parrot.