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Assessing visual function in pigeons: reflex-based and behavioural tests for wildlife triage

Abstract

Assessment of visual function is an important component of triage in avian wildlife casualties, particularly in pigeons where ocular and periocular trauma is common following collision-related injury. Accurate evaluation of vision influences treatment decisions, rehabilitation planning, and release suitability; however, practical visual assessment methods suitable for wildlife rehabilitation settings remain poorly standardized. This study evaluated the clinical utility of reflex-based and behavioral tests for assessing visual function in pigeons, and compared their findings with ophthalmic examination and long-term behavioral observations. Thirty-eight adult pigeons comprising feral pigeons (*Columba livia*), domestic pigeons (*Columba livia domestica*), and wood pigeons (*Columba palumbus*) were assessed using menace response, dazzle reflex, visual tracking, obstacle avoidance, and seed pecking behavior. Ophthalmoscopic examination was performed by a veterinary ophthalmologist, and findings were compared with behavioral observations recorded by experienced wildlife rehabilitators during routine care. Behavioral assessments conducted over time demonstrated greater sensitivity for detecting visual impairment than brief clinical reflex testing alone. Species-related differences were identified: wood pigeons showed reduced reliability in reflex-based testing but greater compliance with behavioural assessments, while feral and domestic pigeons more consistently demonstrated reflex responses but were less cooperative during behavioral testing. Ophthalmoscopic lesions did not consistently predict functional visual impairment. These findings support a staged assessment protocol combining reflex-based examination with behavioural observation to improve clinical decision-making during pigeon triage. Incorporating both approaches may allow more accurate assessment of visual function and more informed welfare-based release decisions.

Keywords: pigeon, avian ophthalmology, vision assessment, wildlife rehabilitation, triage, visual impairment, *Columba*

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Introduction

Vision plays a fundamental role in the ecology and survival of wild birds, and enables individuals to navigate flight, forage, locate prey or evade predation, and exhibit reproductive behaviours. Compared to other vertebrates, the avian globe is larger relative to body mass and cranium size: this adaptation is thought to be, in part, an adaptation for the high velocities reached during flight in many species.[1] The avian retina is among the most complex, often up to twice as thick as in other vertebrates,[2] reflecting their reliance on high spatial resolution for foraging.[3] Therefore, any impairment of visual function has significant consequences for survival in wild birds. Pigeons make up a large proportion of the casualties admitted to wildlife rehabilitation centres (WRCs) in Britain. In one study analysing admissions data for a large WRC in the U.K., 16% of all admissions were either wood pigeons (*Columba palumbus*) or feral/domestic pigeons (*Columba livia domestica*).[4] Trauma is a major cause of morbidity and mortality in wild birds admitted to WRCs, with vehicle collisions and window strikes most common both in the UK[5] and elsewhere.[6,7] Ocular trauma is common: one study found that nearly 30% of the raptors admitted to a veterinary hospital in Spain with traumatic injuries had ocular or periocular damage.[8] 'Triage' of wildlife casualties is the decision-making process by which veterinary professionals and wildlife rehabilitators decide whether an animal should be treated or humanely euthanised following admission. The likelihood of successful rehabilitation and release is a major factor in triage and most WRCs have a euthanasia policy which includes all non-releasable wildlife. Although monocular vision in pigeons is thought to be sufficient for peck localisation[9] and controlling flight velocity when landing,[10] It is widely accepted that any visual impairment significantly decreases the chances of survival in the wild in prey species, and reports of free-living wild birds found surviving with ocular trauma are generally limited to raptors.[11] Assessment of visual function is therefore a crucial part of wildlife triage and ongoing assessment during rehabilitation.

WRCs often rely on non-veterinary staff to triage new admissions, and full ophthalmic examination may not always be practicable. Additionally, in one study, ophthalmic examination alone was reported as poorly sensitive to declining visual acuity in ageing pigeons.[12] Reflex-based tests (such as menace response) are commonly used to determine visual status in domestic species,[13,14] however one study involving feral and domestic pigeons indicated limited use, with only 69% of menace tests producing a positive response in clinically healthy birds.[15] Visual acuity in domestic pigeons has been measured experimentally using grating stimuli,[16,17,18] however this cannot be easily replicated in a triage setting. Behavioural differences between species may further complicate assessment of vision. A large proportion of Columbiformes admitted to WRCs in the UK are wood pigeons,[1] which are reported by wildlife rehabilitators to show greater levels of stress in captivity and during handling compared to feral and domestic pigeons.[19] Increased stress could influence behavioural responses and make interpreting certain tests of visual acuity more challenging in this species. It is possible that hands-off behavioural tests might provide more useful information to a wildlife rehabilitator about the ability of an individual to survive in the wild: in another study, flight analyses of barn owls in a captive environment showed no significant difference between binocular and monocular owls.[20] However, to date, no study has compared the usefulness of reflex-based and behavioural tests to assess visual acuity or the correlation between ophthalmic lesions and functional visual impairment in pigeons. The main objectives of this study were to investigate:

I. different reflex-based and behavioural tests as methods of assessing visual function in pigeons, including menace response, dazzle reflex, visual tracking, obstacle avoidance and seed pecking behaviours;

II. differences in compliance and reliability for each test between feral pigeons, domestic pigeons and wood pigeons; and

III. the relationship between visual lesions detected on ophthalmic examination and functional impairment of vision. Finally, this study aimed to develop a practical, evidence-based protocol to assist veterinary professionals and wildlife rehabilitators in assessing visual status in pigeons.

Material and methods

Study design

The study included 38 captive adult pigeons (23 feral pigeons, 10 domestic pigeons and 5 wood pigeons) housed at a wild bird rescue in the UK. Most pigeons included were considered unsuitable for release. All birds had spent at least three months at the rescue prior to the study, and none had previously undergone ophthalmoscopic examination. A small number of pigeons were excluded from the study where unnecessary handling might have compromised their rehabilitation. All pigeons were provided with free access to food and water in their enclosures prior to examination and behavioural testing which was conducted in an adjacent outbuilding.

Clinical examination

Each pigeon was captured from its enclosure, and a general clinical examination was performed by the first author (E.B.), a final-year veterinary student. Any abnormalities were recorded and made available to the wildlife rehabilitator responsible for the birds' care.

Neurological examination

An abbreviated neurological examination was also performed on each bird. Mentation, posture and gait were examined in the birds' enclosures. Posture was assessed for torticollis, head tremor and failure to stand erect. Gait was assessed for ataxia and paresis.

Four reflexes reported to be consistently present in clinically healthy pigeons were then assessed: hemi-hopping, oculocephalic, foot placement and palpebral.[5] Each reflex was performed three times on the left and right sides, and ≥1 positive response was interpreted as an overall positive result for that side. Hemi-hopping was assessed by holding one leg up with the contralateral foot plantar to the ground and moving the body laterally towards the weight-bearing limb. The oculocephalic reflex was assessed by moving the body laterally to induce physiological nystagmus and compensatory neck movement. Foot placement was assessed by placing one foot dorsally to the floor to encourage replacement to a plantar position. The palpebral reflex was assessed by touching the medial canthus of each eye and recording movement of the eyelid or nictitating membrane across the globe as a positive response. Where individual pigeons could not perform certain reflexes due to physical disability (e.g. anophthalmos or foot amputation), these were excluded from the neurological assessment. Pigeons were classified as neurologically 'normal' or 'abnormal' depending on whether they passed all applicable aspects of the examination.

Visual function tests

All reflex-based and behavioural assessments were carried out by E.B., who was aware of the health status and long-term behaviour of the birds. The order of tests was rotated within each species to minimise the effects of fatigue or stress. The menace response, dazzle response and visual tracking tests were performed three times for each eye. A result was considered positive for that eye if ≥1 positive response was observed. Birds were also recorded to have an 'overall positive' result for each test if ≥1 positive response was observed from either eye.The menace response was assessed by covering one eye and rapidly moving a hand towards the uncovered eye. Closure of the eyelid or movement of the nictitating membrane was considered a positive response. The dazzle response was assessed by the investigator covering one eye and directing the beam of a pen torch towards the uncovered eye. The same criteria used for the menace response were used to identify positive dazzle responses. Visual tracking was assessed by moving a cotton ball suspended by a long piece of string in an arc in alternating directions in the dorsal plane across the pigeon's visual field at 10cm from the eye (Figure 1). For each trial, a positive result was recorded if the pigeon moved its head or ipsilateral eye in the same direction as the cotton ball for ≥50% of each arc in at least one direction. Obstacle avoidance was assessed by placing fabric blocks in a cage to create a single clear path (Figure 2a). Each bird was placed at one end of the path and observed for 120 seconds or until the bird had taken at least five steps. The number of times the bird's beak or head contacted the cage sides and fabric obstacles was recorded. Pigeons that became stressed and were removed earlier were additionally recorded as 'non-compliant'. Seed pecking was assessed by placing 100 mixed seeds in a 10cm ^{2} area in the centre of an empty cage (Figure 2b). Each bird was placed in the cage for 300 seconds and the number of successful pecking attempts (where the bird picked up the seed) and total pecking attempts (where the bird pecked at anything on the cage floor) were recorded. From these values, a seed pecking success rate (%) was calculated for each bird.

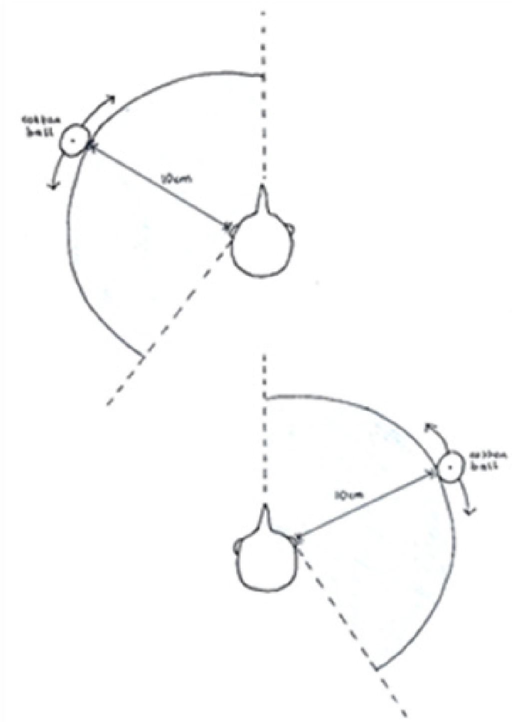

Figure 1 Visual tracking test repeated for the left and right visual field.

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Figure 2a Arrangment for testing.

Figure 2b Seed pecking behavior.

Ophthalmoscopic examination

The second author (D.W.), a certified veterinary ophthalmologist, examined each pigeon using direct ophthalmoscopy to inspect the fundus, lens and adnexa of each eye. Lens opacity was assessed based on the clarity of the pecten. Any abnormalities were noted. Each eye was assigned a lesion score from 0-2 depending on lesion severity, with 0 = no visible lesions, 1 = lesion(s) likely representing mild-moderate visual impairment, and 2 = anophthalmos or lesion(s) likely representing severe visual impairment or functional blindness. A total lesion score for each bird was calculated by adding the left and right score. The ophthalmologist recorded whether each bird was likely to have functional vision in each eye.

Wildlife rehabilitator behavioural assessment

The wildlife rehabilitator responsible for the pigeons' care identified birds with suspected severe bilateral visual impairment. This classification was based on long-term behavioural observations, including colliding with objects, difficulty locating seed and altered flight patterns.

Statistical Analysis

All calculations and figures were performed using R v.4.2.1 with the packages *binom* and *ggplot2*. The significance threshold was set at 0.05 for all statistical tests. 95% confidence intervals were calculated for each recorded sensitivity and specificity using the exact binomial method. Assessments by the veterinary ophthalmologist were compared with overall (all-species) results for each test. Assessments by the wildlife rehabilitator were analysed separately using the same statistical methods and were compared with the ophthalmologist's classification using Cohen's kappa coefficient to determine inter-observer agreement.

Menace, dazzle and tracking responses, and attempting to peck seed, were correlated using Fisher's exact test. The overall sensitivity and specificity for each of these tests were calculated according to each assessment. The seed pecking success rate was not assessed, since only birds believed to have functional vision attempted to peck seed. Non-compliant pigeons were included in statistical analyses for the obstacle avoidance test. The number of head-on obstacle collisions were correlated using the Wilcoxon rank-sum test. The overall sensitivity and specificity for total obstacle avoidance was recorded. Species were compared for compliance and participation in each test. The same statistical analyses were applied to the neurologically normal and neurologically abnormal subgroups to determine whether neurological status affected the reliability of each test.

To determine whether monocular pigeons were able to complete the behavioural tests, statistical analyses for obstacle avoidance and seed pecking were repeated for birds with functional vision bilaterally, The total lesion scores were compared with the number of obstacle collisions (Spearman's rank correlation) and the absence of a menace response, dazzle response, visual tracking and seed pecking respectively (Wilcoxon rank-sum test).

Results

Of the 38 pigeons included, nine birds (24%) had abnormal neurological examinations, with torticollis (n = 3), head tremor (n = 2), ataxia (n = 1) and absent reflexes (n = 5) observed. Neurologically abnormal birds were included in all subsequent analyses unless stated otherwise. Ophthalmic lesions were detected in fifteen birds (39.5%) (Table 1). Based on ophthalmoscopy, five pigeons were considered to have bilateral vision loss (3 feral, 1 domestic and 1 wood pigeon) and two feral pigeons had monocular vision. The wildlife rehabilitator identified three pigeons as having bilateral vision loss (1 feral and 2 domestic), with agreement between the ophthalmologist and rehabilitator on two birds. Cohen's kappa coefficient for bilateral vision function status as assessed by the ophthalmologist and wildlife rehabilitator was 0.445 ($p = 0.00428$), suggesting moderate agreement.

Table 1 The number of birds found with each lesion either unilaterally or bilaterally, by species

Lesion	No. feral pigeons	No. domestic pigeons	No. wood pigeons	Total
Lens opacity	5	2	1	8
Miosis	2	1	0	3
Mydriasis	1	0	1	2
Anophthalmos	1	0	1	2
Melanotic iris	0	1	0	1
Red iris	1	0	0	1
Keratitis	1	0	0	1

Tests of visual function

The results of the visual function tests are summarised in (Table 2) and (Figure 3). Eight birds (21%) were non-compliant in the obstacle avoidance test. Only eleven birds (29%) attempted to peck seed, with all successful at least once. Four out of five reflex-based

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and behavioural tests (menace response, dazzle response, attempting to peck at seed and obstacle avoidance) were positively associated with vision according to both the ophthalmologist's and wildlife rehabilitator's assessments. Visual tracking was positively associated with vision according to the wildlife rehabilitator's assessment but negatively associated with the ophthalmologist's assessment.

Table 2 Diagnostic performance of each test of visual function using the ophthalmologist assessment and the wildlife rehabilitator assessment as reference standards. Sensitivity and specificity relate to the presence of visual function. All pigeons are included in these calculations, irrespective of neurological status or task compliance. p-values were calculated using the Wilcoxon rank test for the number of obstacle collisions and Fisher's exact test for all other metrics

Reference standard	Sensitivity	95% CI	Specificity	95% CI	p-value
Ophthalmologist assessment					
Menace response	**91%**	76-98%	40%	5-85%	0.1195
Dazzle response	70%	51-84%	60%	15-95%	0.315
Visual tracking	21%	9-39%	80%	28-99%	1
Number of obstacle collisions	-	-	-	-	**0.0274**
Obstacle collisions = 0	82%	65-93%	60%	15-95%	-
≥1 seed peck attempts	33%	18-52%	**100%**	48-100%	0.2949
Wildlife rehabilitator assessment					
Menace response	**94%**	81-99%	**100%**	29-100%	**0.0012**
Dazzle response	71%	54-85%	**100%**	29-100%	**0.0339**
Visual tracking	23%	10-40%	**100%**	29-100%	0.2286
Number of obstacle collisions	-	-	**-**	-	**0.0003**
Obstacle collisions = 0	83%	66-93%	**100%**	29-100%	-
≥1 seed peck attempts	31%	17-49%	**100%**	29-100%	0.5423

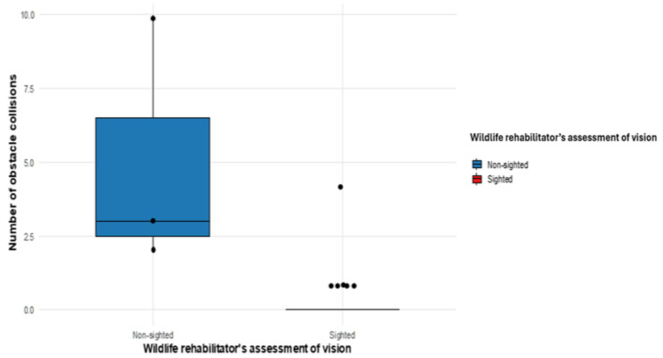

Figure 3a Number of obstacle collisions by visual status, using the veterinary ophthalmologist's assessment.

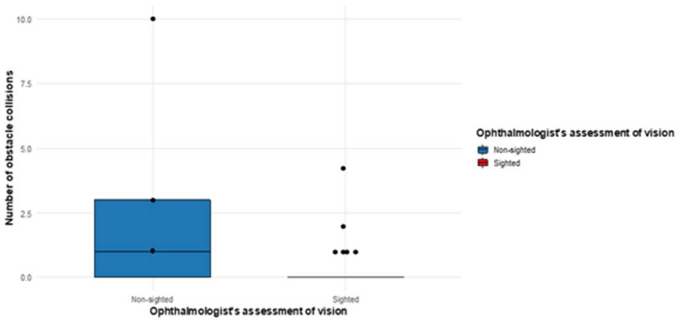

Figure 3b The wildlife rehabilitator's assessment as reference standards. Only data points ≥1 collisions are displayed.

Ophthalmologist's assessment of visual function

When compared to the ophthalmologist's assessments of visual function, only the number of obstacle collisions was significantly correlated with visual function. The menace response was the most sensitive for vision but poorly specific. Only the seed test had a specificity of 100%. However, when neurologically abnormal birds (including 4/5 non-sighted birds) were excluded, all tests were 100% specific for vision and the menace response remained the most sensitive (89%, CI 72-98%.)

Wildlife rehabilitator's assessment of visual function

When compared with the wildlife rehabilitator's assessment of visual function, the menace response, the dazzle response and the number of obstacle collisions were all significantly correlated with visual function. The menace response test had the highest sensitivity for vision, and all tests had a specificity of 100%.

Binocular versus monocular vision

Of the two birds identified by the ophthalmologist as monocular, menace, dazzle and visual tracking responses were positive only on the side with functional vision. Neither bird was compliant in the obstacle avoidance task and both collided at least once. Neither pigeon attempted to peck seed. The total number of obstacle collisions was significantly correlated with binocular vision ($p = 0.0006$).

Species differences

Wood pigeons were generally less likely to produce positive responses in the reflex-based tests compared to feral and domestic pigeons. While 3/4 wood pigeons deemed to have binocular vision showed an overall positive menace response, only 1/4 showed a positive response in both eyes, compared to 16/18 feral pigeons and 7/9 domestic pigeons with binocular vision. Only 1/4 binocular wood pigeons showed an overall positive dazzle response (compared to 14/18 feral pigeons and 6/9 domestic pigeons). No binocular wood pigeons showed visual tracking in either eye, compared to 3/18 feral pigeons and 4/9 domestic pigeons. In contrast, wood pigeons showed relatively higher compliance in behavioural tests. All 5 wood pigeons complied with the obstacle avoidance task, compared to 17/23 feral pigeons and 8/10 domestic pigeons. A higher proportion of wood pigeons attempted to peck seed (2/5), compared to feral pigeons (7/23) and domestic pigeons (2/10).

Correlation with ophthalmic lesions

Total lesion scores for each bird ranged from 0-3 out of 4. Birds with higher total lesion scores had significantly more head-on obstacle collisions than birds with lower scores (p = 0.0163). Birds without collisions had a median total lesion score of 0, while birds with at least one collision had a median score of 2 (Figure 4), and the difference between these groups was statistically significant (p = 0.0239). Birds with positive menace responses had a lower median score (0) than those without (1), however the difference was not statistically significant. Birds with overall positive visual tracking had a higher median score (0.5) than those with negative tracking (0), although this was also not statistically significant. Median scores did not differ between positive and negative overall results for seed pecking or dazzle responses.

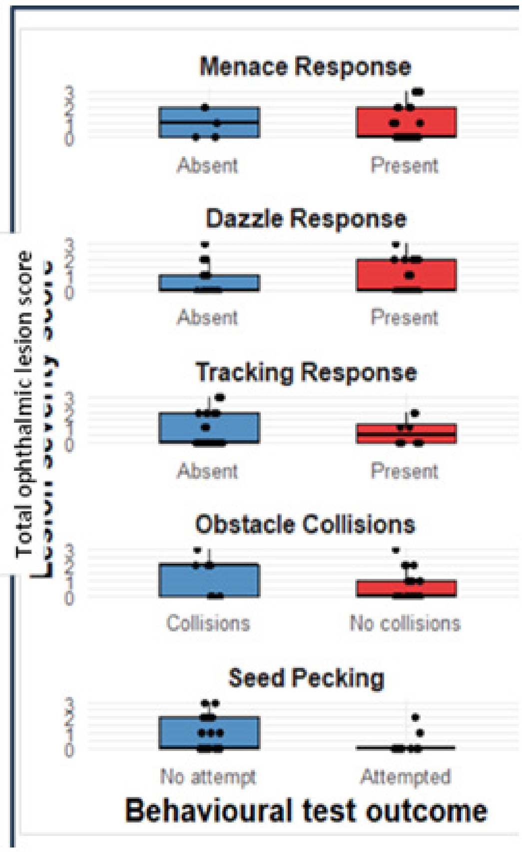

Figure 4 Association between total ophthalmic lesion scores and test outcomes.

Discussion

This study evaluated reflex-based and behavioural tests to assess visual function in pigeons, explored species differences, and investigated the importance of ophthalmoscopic examination during triage of wild pigeons. Long-term behavioural assessment appeared to be a stronger reference standard for visual function than ophthalmoscopic examination alone. Among the five tests, the menace response was the most reliable predictor of visual function, followed by obstacle avoidance and the dazzle response. However, no single test perfectly predicted visual impairment, emphasising the importance of combining several tests during triage. Wood pigeons complied more readily in behavioural tests but performed less reliably in reflex-based tests compared to feral and domestic pigeons, possibly due to stress during handling.[19] Therefore, hands-off behavioural assessments may be more accurate for wood pigeons, while menace and dazzle responses may be more appropriate for feral and domestic pigeons. The lack of visual tracking in any species may be related to the size of the object used, as reported in existing literature.[21] Nevertheless, a combination of reflex-based and behavioural tests should be used to identify pigeons with visual impairment, considering any positive response (menace response, dazzle response, complete obstacle avoidance or attempting to peck seed) as indicative of vision. In a triage setting, this could involve initial menace and dazzle response tests, followed by behavioural testing if results are equivocal (Figure 5).

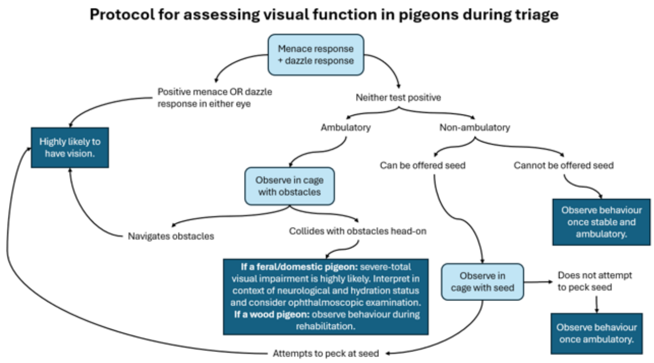

Figure 5 Suggested decision-making flowchart for assessing visual function during triage of feral, domestic and wood pigeons.

Ophthalmic lesions were correlated with increased obstacle collisions, but many birds with structural lesions retained visual function. Lens opacity was the most common lesion identified, and existing research suggests that these changes may have little impact on visual acuity:[12] one study in raptors admitted to WRCs considered many subtle ophthalmic lesions to be incidental findings.[22] Changes in pupil size were the only findings in birds assessed as blind by the wildlife rehabilitator, and one bird with presumed blindness had no detectable lesions despite failing all reflex-based and behavioural tests. These findings suggest that ophthalmic examination alone is insufficient for assessing visual function during triage. Lower specificities in some tests according to the ophthalmologist's assessment may suggest that sighted birds were misclassified as blind based on ophthalmoscopic examination. Notably, all three birds identified as non-sighted only by the ophthalmologist were neurologically abnormal, with bilateral miosis in two. Excluding neurologically abnormal birds yielded 100% specificity for all tests for visual function. This suggests that neurological abnormalities may correlate with ophthalmic abnormalities that do not substantially impair functional vision, consistent with studies in humans with traumatic brain injury and changes in pupil size.[23]

This study was limited by sample size, particularly the number of wood pigeons and non-sighted birds. The lack of investigator blinding was mitigated by measuring objective variables in each test where possible. The wildlife rehabilitator assessment was obtained from the single individual responsible for the birds' care and did not consider inter-observer agreement. The seed pecking test had low participation, possibly due to the availability of seed prior to testing.[24] The time limits for each behavioural test were implemented to replicate a triage setting but may have affected participation. The birds' prior captivity may have affected responses to handling, and no squabs or juvenile birds were included. Finally, not every test is appropriate for all cases: offering seeds may be dangerous in emaciated patients[25] or those with oral lesions,[26] and the obstacle avoidance task is inappropriate

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for non-ambulatory birds. Each assessment should be evaluated alongside comorbidities, and ophthalmoscopic lesions should not be over-interpreted as indicators of visual impairment.

Conclusion

A staged approach involving reflex-based and behavioural tests is recommended for assessment of visual function in pigeons. Species differences should be considered during triage: wood pigeons perform less reliably in reflex-based tests, whereas feral and domestic pigeons are less compliant for behavioural tests. Crucially, ophthalmoscopic lesions do not always correlate with functional vision, and long-term behavioural assessments may be more sensitive for detecting visual impairment. These findings offer an evidence-based framework for wildlife rehabilitators and veterinary professionals to evaluate visual function in pigeons and make informed triage decisions, supporting better patient outcomes.

Ethics approval statement

This project was granted ethical approval by the University of Cambridge Veterinary School's Departmental Ethics & Welfare Committee [reference number: CR994].

Acknowledgments

None.

Conflicts of interest

No conflict declared.

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