A Morphometric Characterisation Study of Feathers of the Barn Owl and the Pigeon

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Abstract – Serrations, or comb-like structures, have formed along the leading edge of owls' wings. Serrations were studied from a morphological and mechanical standpoint, but no quantitative comparisons across species were made. Comparative studies of serrations from species with varying sizes and activity patterns may provide fresh insights into the function of serrations. Pigeons and barn owls both have about the same amount of flying feathers, but the barn owls are somewhat bigger. The barn owl's wing area was much greater than the pigeon's. The barn owl's pennula was so lengthy that it often covering the following three or four barbs, whilst the pigeon's radiates were contained to the region between two barbs.

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INTRODUCTION

The silent flying of owls (Strigiformes) is well-known. Quantitative sound measurements of flying owls, conversely, are uncommon. The owl's primary noise frequency range was 50–1500 Hz, whereas the duck's was 3–5 kHz. The tawny owl's strength was drastically lowered at all frequencies over 1.5 kHz. Mallard ducks, conversely, had a high level of intensity over the frequency spectrum. The noise for frequency bands above 1.6 kHz was much lower for the owl, with a noise reduction of a few dB, according to these investigators. The owl's noise was so low at high frequencies over 6.3 kHz that it couldn't be measured using the microphone array utilized. The flight noise is lowered within the normal hearing spectrum of the owl's prey and within the owl's own optimal hearing range by dampening the noise intensity above 1.6 kHz (Konishi, 1973). The processes governing noise reduction in owl flying are difficult to decipher. Several morphological adaptations of the plumage have been described for these birds that are thought to play a key role in noise reduction during flying via either air-flow regulation or noise reduction. Serrations along the leading edge of the wing, a velvety dorsal surface of each feather, and fringes of the inner vanes of remiges were originally described by Graham (1934). Except for fish-eating owls, who likely do not depend on a quiet flight, these plumage features are unique and have been qualitatively recorded for practically all species of owls (Sick, 1937).

There are around 200 species of owls in the order of birds of prey. Owls come in a wide variety of sizes. The pygmy owl is the smallest owl. The eagle owl is the biggest owl. As a result, our initial hypothesis was that the size of an owl species may impact the serration morphology. Furthermore, various owl species may be found in a wide range of ecological niches, including deserts, woodlands, and tundra. Some owl species, such as the boreal owl *(Aegolius funereus)*, are entirely nocturnal, while others, such as the tiny owl, are diurnal *(Athene noctua)*. The more diurnal owls lack the nocturnal owls' highly evolved adaptations to hunting through listening. Because quiet flying is less necessary when hunting in diurnal owls, we predicted that serration development may be influenced by an owl's activity pattern, with nocturnal owls having more developed serrations than diurnal owls.

REVIEW OF LITERATURE

Sedghi et. al. (2020) The plumulaceous and pennaceous sections of contour feathers of birds. The discrepancies in heat transmission and air permeation characteristics between these two portions of feathers are due to structural variations. The aim of this research is to look at air permeability in such constructions. The knowledge learned will be valuable in the production of garment textiles as well as heat insulators. The essay starts with a fiber simulation that aim to create a structure that looks like bird feathers. The numerical simulation results are then compared to experimental findings for ostrich and magpie plumulaceous feathers. The results show that the permeability of bird contour feathers rises as the distance between the bird skin and the feather tip rises. Fiber diameter and volume fraction had the biggest influence on permeability of the

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characteristics studied, while barb-barbule angle has the least.

The study by Narayanan et. al. (2015) shows how to employ leading edge serrations to minimize wideband noise induced by the interaction of the aerofoil's leading edge with impinging turbulence. Experiments are conducted on a flat plate in an open jet wind tunnel. Grids are used to produce isotropic homogeneous turbulence. Serrations on the leading edge are shaped like sinusoidal wavelength and amplitude profiles, 2h. In order to understand the impact of leading edge serrations on noise reduction features, the frequency and amplitude characteristics are compared to straight edge baseline flat plates. Noise reductions are minimal at low frequencies but significant in the mid frequency range (500 Hz–8 kHz) for all of the samples studied. In general, the sound power reduction level (PWL) is responsive to the amplitude, 2h of the leading edge serrations, but less so to the serration wavelength. As a consequence, the leading edge amplitude is a critical parameter for enhancing noise reduction levels in flat plates and aerofoils, as shown in this paper.

Chen, et. al. (2012) were examined to study the impacts of specific wing feather qualities on owl quiet flying (Buteo buteo). The findings demonstrate that during flying, the eagle owl makes less noise than a typical buzzard, and its wing feathers have higher sound absorption characteristics. This study may offer not only inspiration for resolving aircraft and engineering machine aerodynamic noise, but also a novel concept for the design of low-noise equipment.

Barn owls are efficient nighttime predators, according to Orlowski et al., 2012. From photopic to scotopic settings, contrast sensitivity and visual acuity both fell somewhat. At mesopic (4 102 cd/m2) conditions, peak grating acuity was achieved. When the brightness was reduced by 5.5 log units, barn owls preserved a fourth of their maximum acuity. Barn owls' visual system, we propose, is optimized to provide as much visual acuity as feasible in low-light settings while compromising resolution in photopic settings.

Despite the fact that some information on the procedures that contribute to a decrease in noise production is available, neither the morphological nor biological processes of the owl's quiet flying are known.

MATERIAL AND METHODS:

The morphological analyses were carried out by constructing barn owl (Tyto alba pratincola Linnaeus) and pigeon wings (Columba livia Linnaeus). The barn owl wings have been collected from the institutes' own colonies previously used in other tests and have been slain with the local authorities' approval (Landespräidium für Natur, Umwelt und Konsumschutz Nordrhein Westfalen, LANUV). Three different animals' wings were prepared. Four pigeons were purchased from a breeder and murdered for this investigation with the help of a LANUV authorization. Eight pigeon wings were collected as a result.

For each species, morphological examinations comprised six remiges and six coverts from various locations. They were also scanned from the dorsal and ventral sides using an Epson flatbed scanner (Epson Perfection 3490 Photo, Seiko Epson Corporation, Tokio, Japan) at 800 dpi.

RESULTS:

Characteristics of feathers

A shaft (rachis) and a vane make up a feather. The rachis separates the inner and outer halves of the vane (Fig. 1B). The quill, which lies at the base of the rachis, is implanted in the bird's skin and hence lacks barbs. The inner and outer vanes were examined for their depth, size, and form. The findings of the feather measurements p10 differed only little (SEM of roughly 6% for the barn owl and less than 3% for the pigeon) (Table 1). As a result, only two of the other positions' feathers were studied.

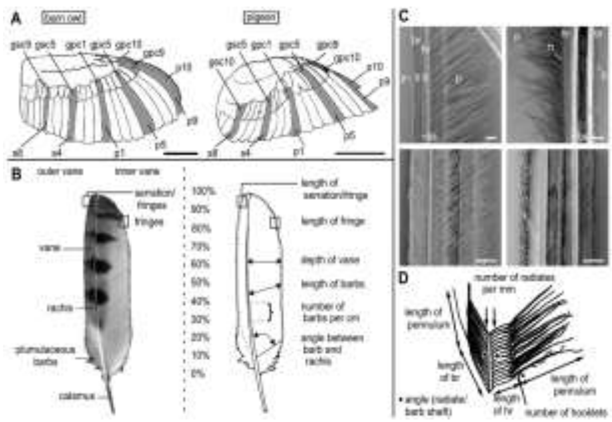

Figure 1: Feather position and feather characteristics measured

Figure 1 depicts the placements of the studied feathers in the barn owl (left) and pigeon (right). (A); scale bar: 10 cm. (B) Parameters on the flying feather were investigated (p5 of a barn owl). Every 10% of the length of the feathers was measured. (C) SEM images of two linked barb (D) Barb parameters were investigated.

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Table 1: Morphometric parameters of barn owls and pigeon's remiges

barn owl		p10	p8	p5	p1	s4	s8
length of rachis	[cm]	24.49a +/- 0.58	27.40	21.06; 22.50	17.36	15.41; 17.64	16.55; 15.96
area of outer vane	[cm²]	10.44a +/- 0.65	19.36; 20.11	18.59; 21.15	12.82; 16.78	14.95; 18.82	16.11; 15.85
area of inner vane	[cm²]	52.15a +/- 3.31	62.60; 63.93	48.15; 55.90	30.79; 38.44	34.73; 40.48	35.35; 38.57
AI (area)		-0.67	-0.53	-0.45	-0.4	-0.38	-0.4
l_{ser}/l_f ov	[mm]	1.8c +/- 0.06	2.83d +/- 0.22	3.62d +/- 0.4	4.23d +/- 0.68	3.29d +/- 0.45	3.21d +/- 0.51
l_f inner vane	[mm]	3.45d +/- 0.15	3.21d +/- 0.18	1.82d +/- 0.16	1.68d +/- 0.2	1.88d +/- 0.28	1.97d +/- 0.3

pigeon		p10	p8	p5	p1	s4	s8
length of rachis	[cm]	19.31b +/- 0.21	19.63	16.71	11.62	11.35	10.33
area of outer vane	[cm²]	4.53b +/- 0.11	7.07; 6.67	8.09; 8.69	8.18; 7.83	10.14; 11.72	9.78; 9.62
area of inner vane	[cm²]	17.58b +/- 0.40	19.08; 21.50	17.18; 20.83	11.18; 11.78	11.53; 12.84	9.89; 10.94
AI (area)		-0.6	-0.5	-0.38	-0.18	-0.05	-0.04

a. mean values with standard error of the mean, N = 5

b. mean values with standard error of the mean, N = 8

c. mean length of serration with standard error of the mean, N = 16 (p10: N = 40)

d. mean length of fringe with standard error of the mean, N = 16 (p10: N = 40)

Both species' feathers were shaped differently. The normalized depth of vanes demonstrates this. The pigeon's maximum depth of feather p10 was identified around 40% of the vane's length, whereas the barn owl's maximum depth of feather p10 was located at around 70% of the vane's length (Figure 2A and 2B). In all eight feathers studied, the inner vane of the pigeon's feather p10 displayed a distinct emargination at 60 percent of its length (Fig. 2B).

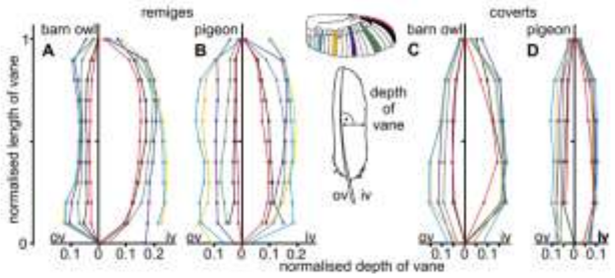

Figure 2 Depth of vane in barn owl and pigeon wing feathers

Characteristics of the barbs

The barbs of the coverts did not exhibit as large interspecific length variation as those of the primary (Fig. 4). To the center of the vane, the normalized length of the barn owl's covert barbs grew somewhat (Fig. 4C). In both the owl and the pigeon, the angle of attachment of the inner and outer vanes dropped virtually linearly. In the barn owl, however, the variances between feathers from various places were minimal (compare Fig. 5C with Fig. 5D).

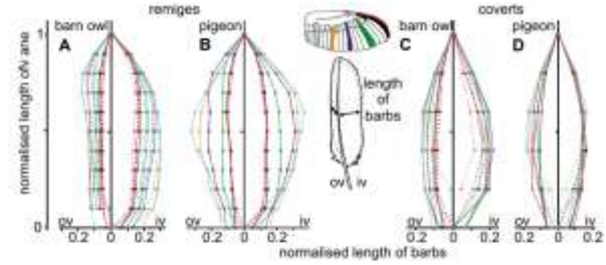

Figure 4 Barb length in pigeon and barn owl wing feathers

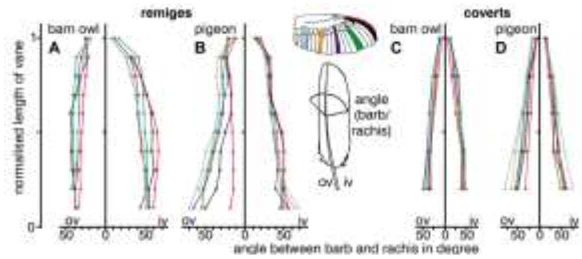

Figure 5 Angle between the barbs and rachis of the barn owls and pigeon's wing feathers

Barbs not only construct the vane, but also the feather edges and hence the wing edges. The barn owl's feathers developed fringes at the margins (Fig. 7B). The tip of a barb creates a fringe. Hook and bow radiates might be seen at the edges. The hook radiates, however, lacked hooklets, so they were not attached. The barb shafts also got thinner as they approached their ends. As a result, the barb ends may float about freely (Fig. 7B).

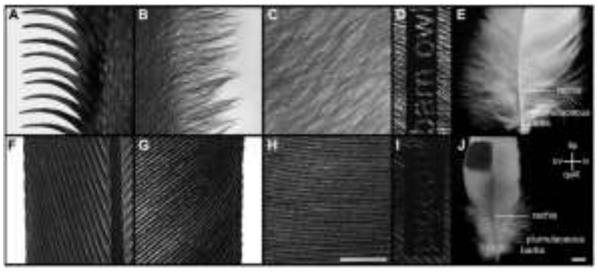

Figure 7: Details of a feather

Characteristics of the radiates

The pennula of the outer vane of feather p10 in both species became shorter as it approached the tip (Fig. 8A). The inner vane of the pigeon's 10th primary's radiating length stayed practically unchanged (Fig. 9A). The radiates of the 10th primary's inner vane of barn owls, on the other hand, became longer as they reached the tip, particularly the hook radiates (Figure 8A and 9A). All of the barn owl feathers that were analyzed had a similar effect. The gpc1 feather, for example, was put near the wrist. As a consequence, the principal covered sections of this feather's base (mainly by median covert feathers) and inner vane (by feather gsc1) were recognized (Figure 1A). The pennula of the inner vane (Figure 9C) was longer than the

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outer vane's (Figure 8C). Based on the density of barbs and the density of hook radiates (29.98/mm on the inner vane of p10), the average density of the pennula in the barn owl was calculated to be 99.8/mm2 (Table 2). The pigeon's homogeneous structure has an average density of 152.5/mm2 (Table 2).

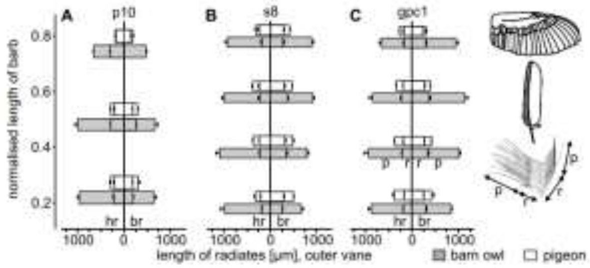

Figure 8 Length of the radiating of the outer vane of three distinct barn owl and pigeon wing feathers

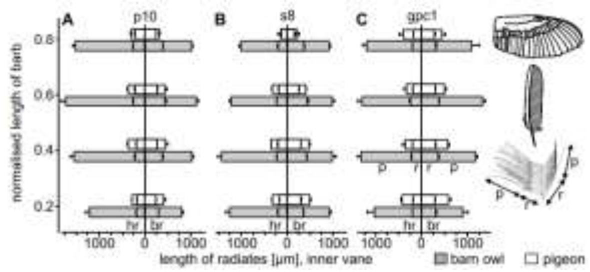

Figure 9 Length of the radiating of the inner vane of three distinct barn owl and pigeon wing feathers

Table 4: Parameters of Pennula

Tyto alba	p10		s8		gpc1	
	outer vane	inner vane	outer vane	inner vane	outer vane	inner vane
density of pennula/mm² *	73.5	99.8	83.3	100.2	79.1	91.5
mean length of pennula [µm] *	601 +/- 57.5	1271 +/- 87.1	785 +/- 41.3	1017 +/- 35.8	799 +/- 67.3	1014 +/- 63.4
Columba livia	**p10**		**s8**		**gpc1**	
	outer vane	inner vane	outer vane	inner vane	outer vane	inner vane
density of pennula/mm² *	84.8	152.5	114.1	109.5	154.5	135.1
mean length of pennula [µm] *	79 +/- 6.6	136 +/- 15.0	171 +/- 7.8	181 +/- 10.7	158 +/- 14.1	201 +/- 22.3

CONCLUSION:

The barn owl had higher asymmetry of numerous characteristics than the pigeon between the outer and inner vanes It is revealed that owl feathers may more readily transport air from dorsal to ventral and vice versa than pigeon feathers. The serrations at the leading edge of the wing, the fringes at the margins of each feather, and the velvet-like dorsal surface are the most noticeable specializations in the barn owl. The barn owl's specializations have been explored in the context of the barn owl's quiet flying. Quantitative data, on the other hand, is lacking. The information supplied here might be used to investigate the impact of each individual feature on the owl's feathers on the air flow field and noise output.

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