

## SHORT COMMUNICATIONS

### A NOTE ON THE EYES OF THE LETTER-WINGED KITE *ELANUS SCRIPTUS*

Since the nocturnal habits of the Letter-winged Kite *Elanus scriptus* were first described by Jackson (1919), there has been little study of the sensory adaptations that might account for this species' hunting success at night. There is little doubt that this bird is nocturnal in its habits and Jackson's report of nocturnal foraging has been confirmed on a number of occasions (e.g. Hollands 1977; Cameron 1974). Except in unusual circumstances, (e.g. Klapste 1979) these birds spend their daylight hours, owl fashion, hidden in the dense foliage of a colonial roost, which is typically in a coolabah *Eucalyptus microtheca*.

Observers have sometimes drawn attention to the Letter-winged Kite's prominent eyes, which appear larger than those of the closely-related diurnal Black-shouldered Kite *E. notatus* (e.g. Hollands 1977; Cameron 1974; but cf. Beruldsen 1971). The size of an eye *per se* is no necessary guide to its light-catching ability, however, since to take just one example, the small eye of an owl-nightjar provides its bearer with a brighter retinal image than would the much larger eye of an eagle under the same conditions. The relevant measure is not the size of the eye, but the ratio of the focal length to the aperture (F-ratio), which is reduced in nocturnally adapted eyes to provide greater retinal illuminance. It is therefore of great interest to have detailed information about more relevant features of the visual optics of the Letter-winged Kite, such as the F-ratio of the eye and the ratio of cone photoreceptors to rod photoreceptors. Both of these ratios are reduced in the eyes of nocturnally-adapted animals (e.g. Walls 1963).

In this report I present some new observations on the eyes of the Letter-winged Kite which were made on partially-preserved material. Comparison with data obtained from seven other nocturnal birds and eight diurnal birds reveals that the optical apparatus of the Letter-winged Kite has a small, but significant, degree of nocturnal adaptation.

#### METHODS

Two eyes, collected from a dead *E. scriptus* at Werribee during the 1976-1977 irruption, were fixed by immersion in 10% formalin. Comparative material, which had been fixed by transcardiac perfusion, was available from seven other nocturnal bird species and eight diurnal bird species. These species are listed in the caption to Figure 1 and Table I. During measurement, the eyeballs were kept at 20-25 cm H<sub>2</sub>O pressure with a 25G needle inserted obliquely at the equator and connected to a cannula filled with 10% formalin in normal saline.

An estimate of an eye's F-ratio requires a measure of both focal length and aperture. The appropriate measure of focal length, for an eye, is the posterior nodal distance (P.N.D.) which can be calculated in a variety of ways (e.g. Hughes 1977). In the present study, detailed measurements of P.N.D. from both *in*

*vivo* and *post mortem* measurements were available for only a few species of owls and hawks (e.g. Pettigrew 1978, 1979). For this reason I used Hughes' (1977) approximation for P.N.D. This approximation ( $0.6 \times$  antero-posterior eyeball distance) generally corresponded accurately with values obtained from avian material by the other methods (the one major exception being the penguin, with its flattened cornea) and was adopted here because it could be used on all material regardless of the quality of preservation. Hopefully more detailed measurements, both *in vivo*, and on properly-fixed material, can be made on *E. scriptus* in the future.

There have likewise been a number of methods of estimating aperture. Strictly speaking, one should measure the diameter of the entrance pupil at its maximal size. This is a relatively inconvenient measure since it requires *in vivo* measurement in darkness, and authors have used other means to estimate aperture, such as the diameter of the lens (cf. Hughes 1977). Estimates of lens diameter have the disadvantage that the lens shrinks after long immersion in many fixatives (such as formalin) and were therefore not used in the present study. As a measure of aperture I adopted the corneal diameter. The corneal diameter is readily determined since the cornea maintains a degree of transparency, or translucency, in even the most poorly fixed material. Moreover, it is possible to satisfy oneself that the diameter of the entrance pupil, at full dilatation, closely approximates the corneal diameter. The diameter of the entrance pupil certainly cannot exceed the corneal diameter, and so the latter measurement may be taken as the uppermost possible limit to the size of the aperture of a given eyeball.

F-ratio was estimated by taking the posterior nodal distance and dividing this by the corneal diameter. To distinguish the F-ratio calculated in this way from F-ratio determined by some other method, I have added the subscript, C, for cornea. Thus:  $F_C$  - ratio.

The poor state of preservation of the retinas of *E. scriptus* precluded a detailed examination of the photoreceptor and ganglion cell layers, but it was possible to examine the *pecten oculi* (Pettigrew 1978). The size of the pecten was measured with a dissecting microscope, along with a count of the number of pecten folds. The size of the pecten has been shown to be related to the number of folds, and both of these measures can be correlated with the degree of nocturnal adaptation (Franz 1934). For example, when a comparison is made between a nocturnal bird and some diurnal close relation, the former invariably has a smaller pecten (see Franz 1934, page number 1167).

#### RESULTS

Over a wide range of eyeball size, posterior nodal distance (P.N.D.) and corneal diameter showed a highly consistent relation which enabled the ready detection of any deviation (Fig. 1). This tight relation between P.N.D. and corneal diameter resulted in a very small degree of intraspecific variation of the ratio (see Table I). Even for material derived from immature Marsh Harriers, where absolute eyeball dimensions are slightly smaller than normal, the  $F_C$  - ratio is exactly the same as in adults (J.D. Pettigrew, unpubl. obs.). The small intraspecific variation in  $F_C$  - ratio is another reason for choosing this ratio as the present basis for comparison, apart from the

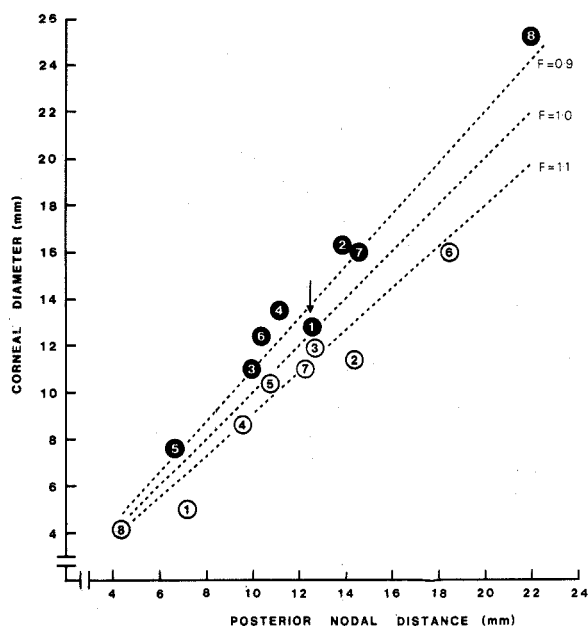


Figure 1. Corneal diameter (a measure of aperture) plotted as a function of posterior nodal distance (a measure of focal length) for the eyes of eight nocturnal (filled circles) and eight diurnal (open circles) birds. Note that the two measures are highly correlated ( $r = .99$ , nocturnal birds,  $r = 0.96$  diurnal birds,  $r = 0.91$ , all data pooled), but that nocturnal birds tend to have larger apertures in relation to focal lengths than diurnal birds. All nocturnal bird values lie above the dotted line ( $F\text{-ratio} = 1.0$ ) where aperture and focal length are equal. The Letter-winged Kite, *Elanus scriptus*, 1, arrowed, therefore has visual optics appropriate to the nocturnal visual adaptation, although its  $F_c$ -ratio of 0.98 is closer to that of the nearest diurnal bird than is any other nocturnal bird studied.

#### Nocturnal Birds (black circles)

- (1) Letter-winged Kite *Elanus scriptus*
- (2) Southern Boobook Owl *Ninox novaeseelandiae*
- (3) Burrowing Owl *Speotyto cunicularia*
- (4) Barn Owl *Tyto alba*
- (5) Australian Owlet-nightjar *Aegotheles cristatus*
- (6) Oilbird *Steatornis caripensis*
- (7) Tawny Frogmouth *Podargus strigoides*
- (8) Great Horned Owl *Bubo virginianus*

#### Diurnal Birds (white circles)

- (1) Feral Pigeon *Columba livia*
- (2) Marsh Harrier *Circus aeruginosus*
- (3) Brown Falcon *Falco berigora*
- (4) Australian Magpie *Gymnorhina tibicen*
- (5) Brown Goshawk *Accipiter fasciatus*
- (6) Wedge-tailed Eagle *Aquila audax*
- (7) Black-shouldered Kite *Elanus notatus*
- (8) White-rumped Swiftlet *Collocalia spodiopygia*

TABLE 1

Data on the eyes of eight nocturnal and eight diurnal birds.  $F_c$  = Ratio of P.N.D. to corneal diameter,  $N$  = number of eyes for each species, S.D. = standard deviation of  $F_c$  for each given species.

	$F\text{-ratio}$	$N$	S.D.	Pecten Folds
<b>NOCTURNAL</b>				
(1) Letter-winged Kite <i>Elanus scriptus</i>	0.98	2	<.01	11
(2) Southern Boobook Owl <i>Ninox novaeseelandiae</i>	0.85	4	0.01	5
(3) Burrowing Owl <i>Speotyto cunicularia</i>	0.90	8	0.01	5
(4) Barn Owl <i>Tyto alba</i>	0.83	8	<.01	4
(5) Australian Owlet-nightjar <i>Aegotheles cristatus</i>	0.88	4	0.02	10
(6) Oilbird <i>Steatornis caripensis</i>	0.86	10	0.02	11
(7) Tawny Frogmouth <i>Podargus strigoides</i>	0.92	4	0.01	3
(8) Great Horned Owl <i>Bubo virginianus</i>	0.87	6	<.01	5
<b>DIURNAL</b>				
(1) Feral Pigeon <i>Columba livia</i>	1.40	4	0.02	16
(2) Marsh Harrier <i>Circus aeruginosus</i>	1.26	8	0.06	16
(3) Brown Falcon <i>Falco berigora</i>	1.07	4	0.02	18
(4) Australian Magpie <i>Gymnorhina tibicen</i>	1.12	6	0.05	22
(5) Brown Goshawk <i>Accipiter fasciatus</i>	1.04	4	0.02	16
(6) Wedge-tailed Eagle <i>Aquila audax</i>	1.16	4	0.01	13
(7) Black-shouldered Kite <i>Elanus notatus</i>	1.11	6	0.01	14
(8) White-rumped Swiftlet <i>Collocalia spodiopygia</i>	1.07	6	0.03	12

Note that there was no intraspecific variation in the number of pecten folds and that intraspecific variation in  $F_c$  is also very small.

elimination of absolute eyeball size as a variable. The tendency for nocturnal birds to have a larger corneal diameter for a given P.N.D. is evident in Figure 1. This tendency resulted in a clear separation of nocturnal and diurnal species on either side of the regression line indicating where corneal diameter and P.N.D. are equal ( $F_c = 1.0$ ). In this respect, the eye of the Letter-winged Kite can be regarded as nocturnally adapted, since its values lie to the left of the  $F_c = 1.0$  division. The extent of the adaptation is not marked, however, since the Letter-winged Kite's optical system, with an  $F_c$  - ratio of 0.98, is only marginally "faster" than some diurnal raptors, like the Brown Falcon ( $F_c = 1.07$ ) or Brown Goshawk ( $F_c = 1.04$ ). (Table I). Perhaps the most valuable comparison is with the Black-shouldered Kite whose  $F_c$ -ratio of 1.11 indicates approximately a 20% change in light-gathering ability since these two species diverged.

The significance of the difference between *E. scriptus* and *E. notatus* is further supported by comparison of the pecten in these two species, since the former, nocturnal, member of the pair has three fewer pecten folds (11 vs 14, see Fig. 2). This places *E. scriptus* alongside well-recognised nocturnal birds like the Owlet-nightjar (10 folds) and the Oilbird (11 folds).

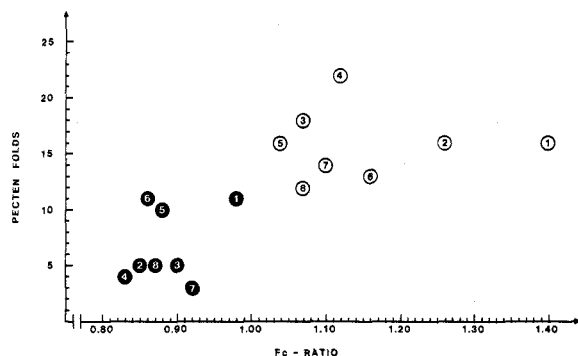


Figure 2.  $F_c$ -ratio (P.N.D./corneal diameter) plotted as a function of the number of folds in the pecten oculi for eight nocturnal (filled symbols) and eight diurnal (open symbols) birds. Note that there is a positive correlation between  $F_c$ -ratio and pecten fold number ( $r = .71$  for all data pooled) although this correlation is weak if the nocturnal birds are considered in isolation ( $r = .31$ ) and absent if the diurnal birds are considered alone ( $r = -0.17$ ). Nocturnal birds all tend to have small pectens, and in this respect, the Letter-winged Kite (1) is no exception.

## DISCUSSION

The close relationship between *E. scriptus* and *E. notatus* makes the present comparison particularly interesting, since any differences in their visual optics have a high probability of being related to their hunting habits. It is clear that *E. scriptus* shows evidence of a greater nocturnal adaptation than *E. notatus* on two counts,  $F$ -ratio and pecten size. It is a pity that preservation of the *E. scriptus* specimens was inadequate to examine the fine detail of retinal anatomy. Apart from the question of rod and cone photoreceptors, it would be of great interest to know, for example, whether *E. scriptus* has two foveae in each eye (like *E. notatus* and all diurnal raptors) or whether it has only one fovea (like owls and frogmouths) (Pettigrew 1979; Bravo & Pettigrew 1981; Pettigrew unpubl.). This question could also readily be settled by ophthalmoscopic examination of a live bird. Since only two eyes from a single specimen of the Letter-winged Kite were available, it might be argued that any interspecific comparisons are invalidated by the possibility of large in-

traspecific variation in *E. scriptus*. This possibility seems remote because of the absence of significant intra-specific variation of  $F_c$  and pecten-fold-number in the other species studied (see Table I). While the absolute dimensions of the eyeball may vary somewhat within a species, particularly at different ages (e.g. see Results for Marsh Harrier), ratios of dimensions such as the  $F$ -ratio, do not; nor does the number of pecten folds vary with age. Future work will be necessary before it can be concluded that the specimen of *E. scriptus* under study here was representative.

The simple measures used in this study, in addition to providing a clear separation between nocturnal and diurnal bird groups, raise questions which might merit further study in the field. For example, there is quite a large variance in the  $F$ -ratio amongst the diurnal birds alone, with a few species approaching "nocturnal" values. This suggests that there may be large interspecific differences in the ability of "diurnal" birds to operate in low light levels. Specifically, the low  $F$ -ratios of the Brown Goshawk and the Brown Falcon suggest that these birds should be able to hunt successfully in dimmer conditions than Marsh Harriers.

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### CAMPBELL'S FAIRY-WREN *MALURUS CAMPBELLI*, A NEW SPECIES FROM NEW GUINEA

*Contributions to Papuan Ornithology no. 8.*  
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This paper reports the discovery of a hitherto unknown malurine wren, *Malurus campbelli*, from New Guinea. It is the first new bird from that great island since E. T. Gilliard discovered the honeyeater *Melidectes princeps* and the bower-bird *Archboldia (papuensis) sanfordi* in 1950. (*Sericornis nigroviridis*, described by A.H. Miller from Edie Creek in 1964, has been shown by Beehler (1976) to be a green-black morph of the Buff-faced Scrub-wren *Sericornis perspicillatus*). Robert Watt Campbell, a bander for the Australian Bird-Banding Scheme, found the wren at the remote outpost of Bosavi, on the rim of the great Papuan Plateau in western Papua New Guinea (6°24'S, 142°50'E). From three visits on 4-11 February 1980, 6 February 1981 and 6-8 November 1981 he netted and banded five individuals, but although measuring and photographing them, he did not take specimens. Other visits proved fruitless, underlining the uncertainty of collecting the species again in the near future. Not only is Bosavi one of the most remote and inaccessible localities in New Guinea but its wren is also particularly elusive, having evaded discovery on more times than it has been found there. In these circumstances we have preferred to describe the species forthwith, in accordance with Articles 11 and 13 of the International Code of Zoological Nomenclature (Stoll *et al.* 1961), despite the lack of a type specimen. Campbell's photograph of what we identify as the type - a putative male - has been printed to near life-size proportions in *Cibachrome II* and distributed to the American Museum of Natural History, New York, the Australian Museum, Sydney, the Australian National Wildlife Collection, Canberra, the Papua New Guinea Public Museum and Art Gallery, Port Moresby, the Rijksmuseum van Natuurlijke Museum, Leiden, and the Museum Zoologicum Bogoriense, Bogor. *Cibachrome*, produced by Ilford Ciba-Geigy Photochemie, uses azo dyes which are stable against light and moisture and can be expected to preserve the image against loss of colour for as long as any specimen.

**Diagnosis** - Closest in appearance to the Broad-billed Fairy-wren *Malurus (Chenorhamphus) grayi*, with which it forms a superspecies. Differs from the later, however, in its pure black, not blue-dusky crown; tawny-brown, not light blue mantle and scapulars; sky blue, not deep blue flanks in putative females; more attenuate ear-tufts; narrower bill (width/length ratio 0.43 vs 0.46 in *grayi*); and lighter body (10-11 g vs 13-14.5 g in *grayi*).

**Description** - *Putative adult males* are uniquely black-headed with light blue stripes on the brow and over the ears; the pattern resembles that of a melithreptine honeyeater (*Melithreptus*) or titmouse (*Parus*). Crown black, fringed with thick, pale turquoise-blue superciliaries that do not meet across the frons; mantle and scapulars mid tawny-brown, contrasting with a deep greyish-blue lower back and mid tawny-brown upper-tail coverts; flight feathers mid grey-brown edged tawnier, the upper-wing coverts plain tawny-brown, and the underwing coverts pale grey; tail mid bluish grey-brown, the feathers edged tawnier and tipped narrowly buff-white; face black from lores to sides of neck, with long lance-shaped pale turquoise-blue ear-tufts arising from the lower eye rim and curving down towards the shoulders; entire ventral surface from chin to crissum delicate powdery sky-blue. Iris blackish brown; bill black; feet deep flesh-grey, grading to paler flesh on toes and claws. Measurements, in mm: wing 54-56, tail 49-50, exposed culmen 15-16 × 6.3-6.5 wide at nares, tarsus 21-22 (from two individuals in life).

*Putative adult females* are like males but have white lower breasts and bellies without any darkening of the sky-blue on the flanks (*cf.* Broad-billed Fairy-wren *Malurus grayi*). Their ear-tufts, too, are not so long and pointed, and their crissa pale tawny-rufous. Measurements, in mm: wing 49-51, tail 44-49, exposed culmen 14-16 × 6.3-6.5, tarsus 21-22 (from three individuals in life).