

Cover illustration

I'll try to accommodate you

A diving, piscivorous bird faces some very special challenges that demand evolutionary creativity. A hunting vertebrate that pursues and captures prey under water must reckon with the loss of corneal refractive power since the cornea has approximately the same index of refraction as water. Hence, such hunters must rely upon lenticular accommodation for the entire dioptric power of the eye under water. But birds face an additional twist compared with predatorial fish. A bird must approximate emmetropia when airborne because its cornea will have refractive power in air as it will have a different index of refraction compared to air. Cormorants and their kin are a model for the successful solution to these problems. Most fish, on the other hand, never face air as a medium and consequently never use their cornea as a refractive surface. The Australian darter (*Anhinga melanogaster*), also known as one of the snakebirds (Anhingidae), seen on the cover is very closely related to cormorants, and allied to pelicans. Snakebirds are strong swimmers and have long, sharp beaks with serrated edges that can grasp or spear their prey. Known from at least the Eocene epoch (35–56 million years ago), snakebird predecessors included several interesting birds known as plotopterids. These birds probably were wing propelled under water and were the giants of the Anhingidae, being as much as 25–65% larger than their modern descendants. Some, located in what is now South America, may even have been flightless, but were extraordinary swimmers because of the emphasis on their semiterrestrial aquatic world.

Darters are widely distributed in the tropics throughout the Old and New World and, as you might imagine, have interesting adaptations to accomplish their foraging. Since all birds float, diving birds, such as darters, must control their buoyancy by altering the

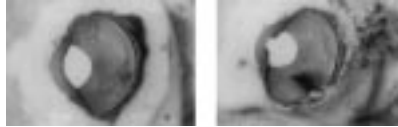


Figure 1 (Left) Sagittal section of the eye of the hooded merganser (*Mergus cucullatus*) without accommodation. (Right) Sagittal section of the eye of the hooded merganser stimulated with nicotine sulphate to approximate accommodation. Note anterior lenticonus. (Photograph by Jake Sivak, PhD)

amount of air in their air sacs and their feathers. The darter's body feathers are relatively wettable and permeable, allowing for the body to be completely submerged leaving only the neck exposed. The curved neck, then, appears snakelike above the water line providing the unusual name that characterises the bird. Of necessity, though, these wet feathers must be carefully dried in the sun when the bird exits the water, and this behaviour is illustrated on the cover. Darters have a functional uropygial gland that produces oil and this oil is used in preening the feathers to ensure effective drying and maintenance of the proper arrangement of the feathers.

Other interesting adaptations include totipalmate feet, which means that the webbing is complete between all four toes to maximise the surface area of the propelling feet. Under water, these feet are used synchronously and provide very rapid propulsion. Darters will swim with their wings partially open creating a shadow. When the shadow passes over small fish, the fish become frightened and try to swim away, stimulating the darter to swing its long neck and impale the victim with one or both mandibles.

Perhaps the most unusual adaptation of the darter, though, is the eye, which is designed to solve the loss of corneal refractive power. When under water, a closely related species, the cormorant, has been found to be capable of at least

40–50 dioptres of accommodation by a most extraordinary mechanism (Levy B, Sivak J, *Comp Physiol* 1980;137:267–720). There is good evidence that some birds may be capable of as much as 70–80 dioptres of accommodation, and if any birds are that capable, darters would be likely to be one of them because of their ecological needs.

The iris is stiff with robust musculature. Accommodation involves tightening the iris sphincter muscle and contraction of the ciliary musculature. The ciliary body contains three striated muscles. When accommodating, these muscular contractions force the ductile lens through the rigid pupil creating anterior lenticonus, as can be seen in the figure on this page (Levy B, Sivak J, *Comp Physiol* 1980;137:267–720). The pecten may play a contributory part by filling with blood and maintaining pressure against the posterior capsule of the lens.

The Australian darter still has secrets to teach us. Walls reports that a related species, the great cormorant, has a large hardarian gland, which is a supplementary tear gland embedded along the superior edge of the nictitating membrane. This gland secretes an oily viscous tear to prevent osmotic dehydration related to immersion in water or even exposure to its own tears for prolonged periods since its tears may be highly concentrated. The lacrimal gland can, at least in a closely related double crested cormorant, outperform the bird's kidney in that it has an active excretory capacity and can excrete a highly concentrated salt solution in its tears allowing the bird to obtain all necessary water from its fishy diet.

So, the darter is an ocular physiological marvel with his tears and his accommodative abilities. Presbyopia probably doesn't worry him.

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