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Glowing in the Light: Fluorescence of Bill Plates in the Crested Auklet (*Aethia cristatella*)

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ABSTRACT.—We examined the fluorescence of ornaments among three auklet species: Least Auklets (*Aethia pusilla*), Crested Auklets (*Aethia cristatella*), and Parakeet Auklets (*Aethia psittacula*) on Gareloi Island, Alaska during the 2015 breeding season. We found that the ornamental bill plates of Crested Auklets fluoresced, but bill ornaments of Least Auklets and bills of Parakeet Auklets did not. We also found that none of the feathers in these three species exhibited fluorescence. We suggest that differences in ornamentation and fluorescence may be related to life-history strategies associated with sexual selection and predator avoidance. *Received 26 November 2015. Accepted 16 April 2016.*

Key words: *Aethia* auklets, bill plates, breeding ornaments, fluorescence, mate selection

Intersexual selection has been widely documented in many bird species (e.g., Savalli 1995), exhibiting exotic plumes, unique behaviors, and other exaggerated breeding related features (Payne 1972). Many birds have evolved, through sexual selection, ornamentation that becomes expressed exclusively during the breeding season in order to self-advertise to prospective mates. Among monogamous species, intersexual selection is a valuable strategy to maximize progeny while reducing energetic costs (Jones and Hunter 1993, 1999). When forming new pairs, individuals rely on extrinsic cues as mate selection is made before the parental ability of either partner can be assessed (Préault et al. 2005). Individual quality can often be inferred from the quality of ornamental features; those that are able to produce and maintain extraneous ornaments highlight their apparent exceptional physiological condition when self-advertising (Andersson 1982).

Additional features may become apparent when viewed in the ultraviolet (UV) spectrum visible to most birds (Bennett and Cuthill 1994, Wilkie et al. 1998). Non-fluorescent pigments reflect only the wavelengths of light associated with their principle color whereas fluorescent pigments reflect their principle wavelength and absorb other wavelengths, re-emitting them as visible light; this results in colors that are much more vibrant than their non-fluorescent counterparts (Arnold et al. 2002). Birds have been shown to incorporate these pigments into breeding plumage to convey information on individual quality (Wilkie et al. 1998), sex (Andersson et al. 1998), and sexual maturity (Jouventin et al. 2005).

In marine birds, genetic evidence of UV sensitive vision appears to be limited to Laridae and Sternidae families, whereas UV sensitive vision has been demonstrated in eight terrestrial avian families (Machovsky Capuska et al. 2011). Here, we present the novel description of ornamental bill plate fluorescence in the Crested Auklet (*Aethia cristatella*) and discuss a possible role in mate selection for this species.

To understand the extent of this phenomenon in *Aethia* auklets (which have drab plumage and variable ornamentation; Jones 1993a, Jones et al. 2001, Bond et al. 2013), we examined ornamental fluorescence in three closely related *Aethia* species that exhibit varying degrees of ornamentation: Least Auklet (*A. pusilla*), Crested Auklet (*A. cristatella*), and Parakeet Auklet (*A. psittacula*). For this study, we defined three degrees of ornamentation as: 1) highly ornamental (Crested Auklet: black forehead crests, white auricular plumes, bright orange bill and rictal plates [Jones et al. 2000]); 2) moderately ornamental (Least Auklet: small white forehead plumes, white auricular plumes, red-tipped bill with a black knob-like structure [Jones and Montgomerie

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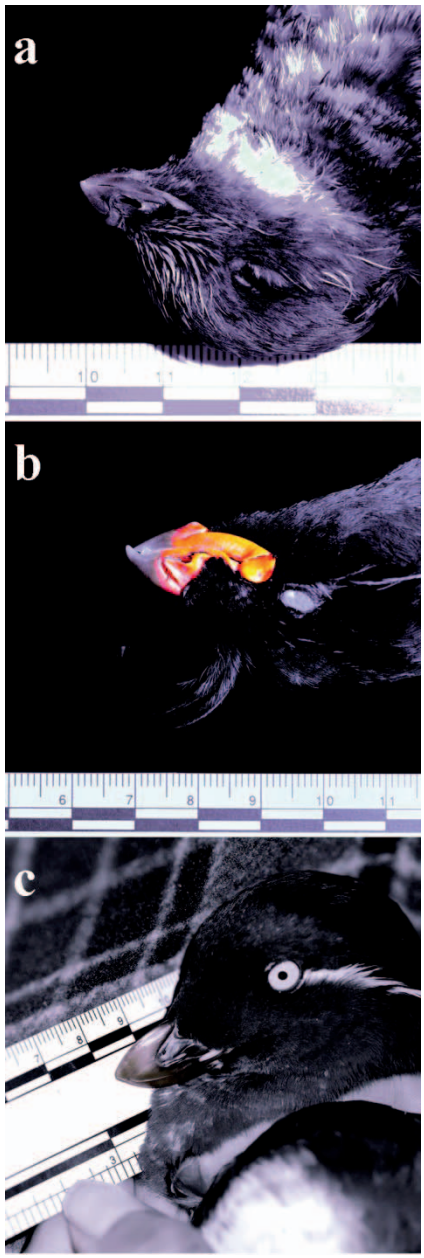

FIG. 1. Fluorescence of ornamental structures of (a) museum-mounted Least Auklet, (b) museum-mounted Crested Auklet, and (c) live Parakeet Auklet. Images were edited with Adobe Photoshop Creative Cloud and the blue color channel was filtered out, leaving only fluorescent areas colored. Specimens were prepared by C. N. Wails, E. D. Gruber, and L. Smith. Photographs by E. Slattery.

1992]); and 3) sparsely ornamental (Parakeet Auklet: white auricular plumes, reddish-orange bills [Jones et al. 2001]).

METHODS AND RESULTS

We observed three species of auklets at Gareloi Island, Alaska (51° 47′ N, 178° 47′ W) from May to July 2015. Auklets were captured using noose carpets set on the colony surface or at nesting crevices as part of larger studies. We briefly exposed the whole body of captured auklets to blue light (440–460 nm) using a GoBe 700 NightSea flashlight (Light and Motion, Marina, CA, USA) and noted parts that fluoresced. Additionally, we recovered recently deceased Least and Crested auklets and photographed the fluorescence of these individuals in the field using a Canon 5DMKIII with a 100 mm f/2.8 lens (Canon USA, Melville, NY, USA). We did not find any recently deceased Parakeet Auklets while in the field and instead photographed live individuals under similar conditions. The blue color channel was filtered out of photographs with Adobe Photoshop Creative Cloud (Adobe Systems Inc., San Jose, CA, USA), leaving only fluorescent areas colored.

We investigated the ornamental fluorescence of Least ($n = 5$; unknown sex), Crested ($n = 23$; 43.5% female, 56.5% male), and Parakeet auklets ($n = 5$; unknown sex). We observed both pre-breeding sub-adults and breeding adults in Least and Crested auklets, as identified by plumage characteristics (Bédard and Sealy 1984), but only breeding adults in Parakeet Auklets.

Feathered ornaments did not fluoresce in any of the species examined in this study and Least and Parakeet auklets completely lacked bill fluorescence (Figs. 1a and 1c). However, the bright orange bill and rictal plates of all Crested Auklet individuals fluoresced when exposed to blue light (Fig. 1b).

DISCUSSION

Evidence for UV sensitive vision (<400 nm; Bennett et al. 1997) in marine birds is sparse and auklets are not among those that show a genetic predisposition for this trait (Håstad et al. 2005). We used blue lighting (~450 nm) which is still

capable of eliciting fluorescence (e.g., Eyal et al. 2015) and could be detected by auklets lacking UV sensitive vision.

The lack of fluorescent ornaments observed on Least and Parakeet auklets likely aids in their cryptic coloration. Least Auklets often nest in mixed-species colonies with Crested Auklets (Jones 1993a, Bond et al. 2013), where conspicuous activity draws attention of avian predators. Least Auklets are smaller and more vulnerable to avian predators than Crested Auklets and may benefit from appearing drab among the more showy Crested Auklets as avian predators, particularly gulls and eagles, possess UV sensitive vision (Machovsky Capuska et al. 2011, Lind et al. 2013). Parakeet Auklets nest in separate, loose colonies where they rarely, if ever, socialize in scrums (Jones et al. 2001); non-fluorescent ornaments and limited social activity may help conceal both the location of their breeding colonies and individuals from predators.

We found that both pre-breeding and breeding Crested Auklets possessed fluorescent bill plates (though sub-adult bill plates are smaller and appear less colorful to the eye than adults; Jones 1993a). For two species of penguin, breeding individuals have larger, more UV-reflective bill spots than non-breeders and thus indicate sexual maturity to conspecifics (Jouventin et al. 2005). Fluorescence of Crested Auklet bill plates could also convey this information, which would be advantageous during mate selection.

Although the purpose of fluorescence of Crested Auklet bill plates is unknown, it seems unlikely that it is an accidental by-product of pigmentation. Experimental results have demonstrated that both sexes select mates based on feathered ornaments (Jones and Hunter 1993) and bill plates may be used similarly. The bill plates, which can vary slightly in brightness and size, are grown shortly before the breeding season and are shed as chicks hatch (Jones 1993a). This development coincides with the timing of early-season scrumming behavior that allows individuals to identify prospective partners (Jones 1993a). Male Crested Auklets have larger, more strongly hooked bills than females (Jones 1993b) and play a greater role in chick brooding (Fraser et al. 2002). The observed fluorescence may showcase this powerful tool to prospective mates, conspecifics during scrumming, and when defending young chicks from conspecifics.

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Male Helmeted Manakins (*Antilophia galeata*) with More Colorful Crowns Have Better Body Conditions

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ABSTRACT.—Bird plumage coloration is an important signal used in communication and may indicate individual fitness. We tested the hypothesis that coloration is related to body condition in male Helmeted Manakins (*Antilophia galeata*). Fourteen adult males were captured in a forest fragment in Brazilian Cerrado from November 2007 to June 2008. Crown feather coloration (brightness, hue, and saturation) was evaluated through spectrophotometry, and body condition was measured via the Relative Mass Index (RMI). Coloration characteristics were positively correlated with body condition, indicating that individuals with higher body conditions have brighter and more saturated feathers, and therefore, can use these traits to signal their good body condition. *Received 29 September 2015. Accepted 17 April 2016.*

Key words: *Antilophia galeata*, coloration, feathers, handicap, Pipridae, RMI, spectrophotometry.

The handicap principle argues that animals can maintain behavioral or morphological traits, which despite being prejudicial to their own survival, express signals that are useful, especially for sexual selection (Zahavi 1975, Zahavi and Zahavi 1997). The most common of these traits in birds are displayed by males with vibrant plumage colors during courtship (Armstrong 2015). In spite of increasing the risk of predation and requiring greater energy cost (Kotiaho et al. 2001), plumage coloration may be an important signal to attract mates (Hill 2006). Females may select males with extreme secondary sexual traits (Pomiankowisky 1987). Males with greater energetic reserves (usually lipids) are assumed to have better fitness, thus they belong to the cohort of mates that are potentially more attractive to females (Millar and Hickling 1990). These intrinsic qualities of males must be signaled to other individuals through secondary sexual traits, such as vibrant feather coloration, which is usually a reliable indicator of fitness, especially in taxa with sexual dimorphism (Grafen 1990, Prum 2012).

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