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Plumage Changes in Double-crested Cormorants (*Phalacrocorax auritus*) Within the Breeding Season: the Risks of Aging by Plumage

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Abstract.—Scant attention has been given to the molting patterns of known-age Double-crested Cormorants (*Phalacrocorax auritus*). In general, subadult individuals are identified with a tan, buffy or mottled chest, and adults are identified with a black chest. While studying Double-crested Cormorant population dynamics in Ontario, Canada, with known-age birds, it was noted that the plumage of many (> 75%) breeding adults changed from black to heavily mottled during the course of the breeding season. No pattern with age was observed; plumage changed in equal proportions for all ages from 2-year-olds to 7-year-olds. A similar but reverse pattern has been observed with Double-crested Cormorants roosting at sites in the southeastern USA during fall migration. Whereas the majority of the roost had juvenile/subadult plumage in September, by mid-January the roost had shifted to 75% adult black plumage. The mechanism behind the plumage change is unknown, but extreme caution is advised when using plumage to age cormorants, especially during the winter months. By describing our observations with Double-crested Cormorants, we hope to encourage future formal research on within-season plumage changes. *Received 31 August 2017, accepted 5 November 2017.*

Key words.—adult plumage changes, Great Lakes region, juvenile plumage, molting patterns, plumage aging, plumage characteristics.

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The ability to age an individual in birds can enhance ecological studies such as population demographics and reproductive biology. Plumage characteristics can be of particular importance to avian researchers. For example, studies with Double-crested (*Phalacrocorax auritus*; King *et al.* 1995), Great (*P. carbo*; Galvan 2004), Pelagic (*P. pelagicus*; Filardi and Rohwer 2001) and Olivaceous (*P. olivaceus*; Morrison *et al.* 1978) cormorants as well as Rock (*P. magellanicus*; Rasmussen 1987) and Red-legged (*P. guimardi*; Rasmussen 1988) shags were all conducted under the assumption that individuals can be aged using plumage alone.

Double-crested Cormorant (hereafter, cormorant) plumage has been loosely described as "Juvenile", "Immature-Subadult (Basic and Alternate I and II)", and "Pre- and Post-breeding Adult (Definitive Basic and Alternate)" (Johnsgard 1993; Dorr *et al.* 2014). Juvenile plumage is inconsistent, but the head is usually a dark brownish gray to pale brown; the throat and foreneck are whitish with varying degrees of brown mottling; the back is generally dark grayish brown; the chest has patchy brown and white mottling; and the remiges and rectrices are dark brown to black (Johnsgard 1993; Dorr *et al.* 2014).

There is extensive individual variation in the immature-subadult plumage (Dorr *et al.* 2014). Although poorly described, subadult plumage is generally darker than juvenile plumage. The throat, foreneck, and chest are typically dull brown or tan; the head and back are usually a mixture of brown and black, and if nuptial crests occur, they are very small. The wing coverts are buff or slate gray with brown or black margins (retained from the juvenile plumage). Some individuals acquire definitive adult plumage by the second year, a few shortly after 1 year, but many after 2 years of age (Johnsgard 1993; Dorr *et al.* 2014).

In the definitive pre-breeding adult plumage, the head, neck, lower back, chest and underparts are all black, with a dull greenish gloss; the upper back, scapulars, and wing coverts are brownish gray with thick black margins; and the remiges and rectrices are brownish black to black. The nuptial crests vary from white to entirely black in different lengths and densities, both within and among the five major North American breeding regions (Dorr *et al.* 2014). Post-breeding adult plumage is noted as being similar to the pre-breeding plumage, except that the ornamental crests are lost shortly after egg laying (Johnsgard 1993; Dorr *et al.* 2014).

The objective of this paper is to add our observations of adult cormorants reverting back to "subadult" plumage during the breeding season to the scientific literature base and to encourage future formal research on within-season plumage changes.

Methods

Study Area

We selected two geographically distinct cormorant breeding areas, located on opposite sides of Ontario, Canada, for study (Fig. 1). The study areas were: Lake of the Woods, near Kenora, in extreme western Ontario (49° 39′ 46.80″ N, 94° 30′ 25.20″ W) and eastern Lake Ontario, near Kingston, in southeastern Ontario (44° 11′ 27.60″ N, 76° 32′ 34.80″ W). Both areas consisted of ground-nesting cormorant colonies on a series of small islands within approximately 15 km of the corresponding cities listed above. The islands are composed of granite slabs and/or limestone outcroppings and ranged in size from 0.2 ha to 3 ha. The Lake of the Woods breeding area is composed of five islands: Manitou Island, Lemmon Island, an unnamed island north of Lemmon Island, Guano Rock and an unnamed island northeast of Bathe Island. The eastern Lake Ontario breeding area is composed of four islands: Snake Island, Pigeon Island, West Brothers Island and Scotch Bonnet Island.

Banding

Beginning in 2000 for eastern Lake Ontario and in 2002 for Lake of the Woods through 2008, we color banded over 7,500 pre-fledged cormorants (Chastant *et al.* 2014). Each year during June and July, we surrounded crèches of flightless cormorants that were close to fledging (~30 days old) and captured individual young, then banded and released them immediately back into the crèche. We banded each cormorant, on separate legs, with a unique aluminum band and a field-readable, tri-laminate plastic color leg band bearing a unique, engraved, alpha-numeric code (Pro-touch Engraving, Inc.). We distributed the banding effort among the various islands according to colony size, with larger colonies receiving more effort.

Resighting

The primary objective of our research was to resight as many color bands as possible to construct an age matrix for a population dynamics study (Chastant *et al.* 2014). We conducted color-band resighting by scanning the legs of cormorants with binoculars and/or a spotting scope. We collected observations from an elevated blind erected prior to nest construction, at a distance that did not cause disturbance to nesting birds (≥ 20 m). Blinds were located on the unnamed island north of Lemmon Island in Lake of the Woods and on Snake Island in eastern Lake Ontario. As each color band had a unique alpha-numeric-code, we could determine the age and natal colony of each resighted bird.

For both Lake of the Woods and eastern Lake Ontario during 2006 and 2007, we collected observations from the blind once a month over the course of the breeding season: in May during nest construction and initial egg laying, in June during late-incubation, in July just before chick fledging, and in September after fledging, during pre-migratory staging. In 2006, we spent a continuous interval of 24 hr in the blind each visit, and conducted observations during periods of daylight. In 2007, observations from the blind were extended to span 24 hr of consecutive daylight over 2 days. In 2008, we conducted band resighting in Lake of the Woods only during the month of July, prior to banding, for 2 days as a consecutive 24-hr daylight period (Table 1). Due to our primary objective of resighting as many color bands as possible, formal data collected about plumage was minimal. When time allowed, we took notes on the birds' plumage and photographs through a scope with a digital camera.

Results

While conducting colony observations for a population dynamics study (Chastant *et al.* 2014), we began to notice plumage changes in a large proportion (> 75%) of the cormorants present in the colonies. Plumage changes occurred in all ages of cormorants, with varying degrees of intensity. In 2006, individuals we observed in May in full breeding plumage with a jet black chest, head and nuptial crests, were by July and September developing mottling on their chest and head. Three examples are included to illustrate this phenomenon: 1) 2-year old (Fig. 2A); 2) 6-year-old (Fig. 2B); and 3) 7-year-old (Fig. 2C). We observed the same colony-wide plumage change pattern again in 2007 and 2008. Of the 534 total individuals observed during the 3 years of our study, 30 were photographed multiple times

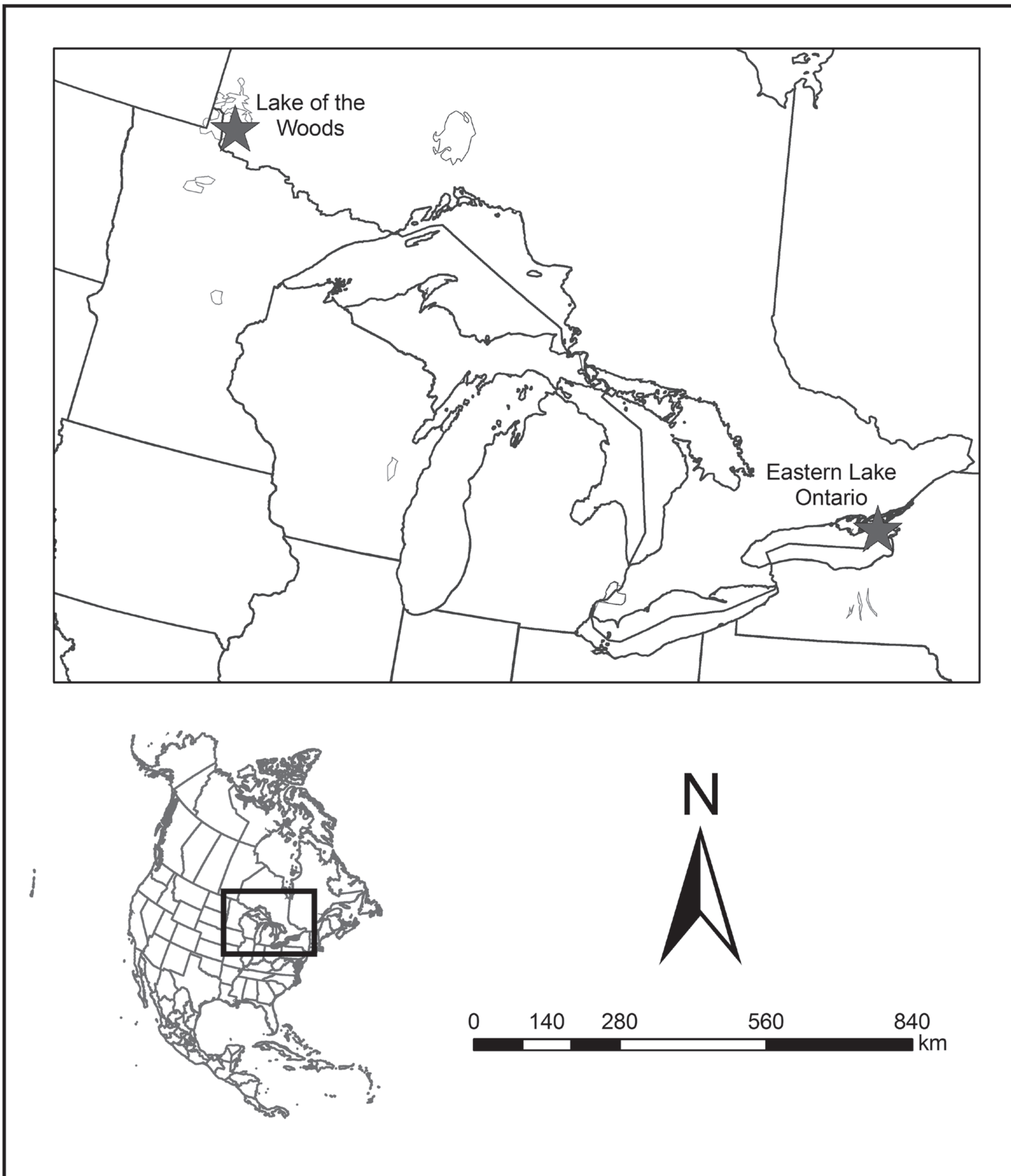

Figure 1. Location of two Double-crested Cormorant (*Phalacrocorax auritus*) breeding areas sampled for plumage characteristics during 2006-2008.

Table 1. Number of daylight hours spent observing Double-crested Cormorant (*Phalacrocorax auritus*) color bands from a blind in Lake of the Woods and eastern Lake Ontario, Canada, during the breeding seasons of 2006-2008.

	2006				2007				2008
Area	May	June	July	Sept	May	June	July	Sept	July
Lake of the Woods	18	19	17.5	13.5	24	24	24	24	24
Eastern Lake Ontario	17	18	17	14	24	24	24	24	n/a

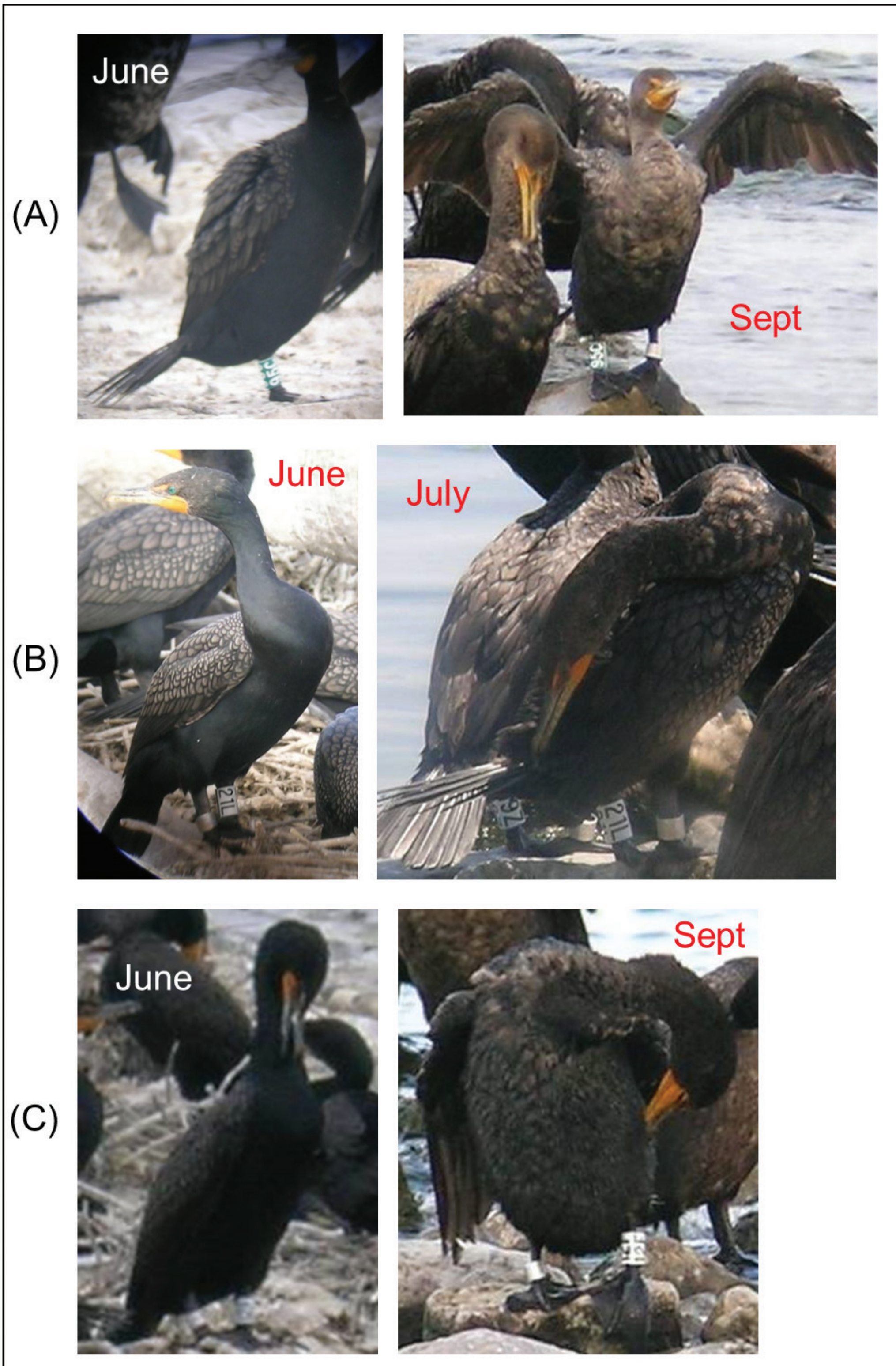

Figure 2. Within 2007 breeding season plumage change: (A) 2-year-old; (B) 6-year-old; and (C) 7-year-old Double-crested Cormorant (*Phalacrocorax auritus*).

throughout a nesting season to document the plumage change (Lake of the Woods = 14 of 210; eastern Lake Ontario = 16 of 324).

DISCUSSION

Since 1991, researchers have noticed that roughly 75% of the cormorants roosting at sites in the southeastern USA, during fall migration through mid-January, had juvenile/subadult mottled plumage. But by mid-January, the roost would shift to 75% adult black plumage (D. T. King, pers. obs.). Satellite telemetry data from these roosting southeastern cormorants have revealed the summer/breeding ranges include the Great Lakes and the Prairie Pothole Region of the Northern Great Plains in the USA (King *et al.* 2010). It was assumed that the age of the roost shifted, but in light of these new breeding ground observations, it may be inappropriate to age cormorants using plumage alone, especially during the winter months. The mechanism driving the observed cormorant plumage change is unknown, but sources of plumage change may include feather-degrading bacteria (Burtt and Ichita 2004; Goldenstein *et al.* 2004), food supply (Hill 1993; Fargallo *et al.* 2007), and testosterone levels (Stoehr and Hill 2001; Peters *et al.* 2006; Bokony *et al.* 2008). We present a groundwork of preliminary observation here; however, further investigation is needed to establish the source of the within-season plumage changes. These observations document an important but otherwise overlooked part of seasonal Double-crested Cormorant plumage variation, which may change the way cormorant and other waterbird research is conducted during the late- and non-breeding seasons.

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